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Environment, Village and City

A Genetic Approach to Urban Geography; with Some Reference to Possibilism *

GRIFFITH TAYLOR

INTRODUCTION

This is an outstanding year because it is marked by the complete economic and military alliance of the United States and the British Empire. They are united in their determination not only to defeat enemy aggression, but also to root out evil developments based on what is false in the Totalitarian sociology. The international crisis makes me, as a Britisher, feel the more honoured to be chosen to present the annual address to this Association of American Geographers.

The geographer studies environment. He believes that it is a vital factor in determining human progress. Some few of us who are willing to proclaim ourselves as, in some measure, "tarred with the determinist brush," think that this has been true right through man's history. But the detailed study of environment, with the production of accurate maps and isopleth charts, is a comparatively recent phase of research. Hence some of our sister disciplines, such as history and anthropology, are not yet willing to give much time to its study, or indeed to grant the necessity for such study.[1]

The present writer has devoted a good deal of attention to the way in

* Presidential address, delivered before the Association at New York, N. Y., December, 1941.

[1] *Historical Geography of England*, edited by H. C. Darby (Cambridge, 1936) is a fine example of the geographical approach to history.

which environment, and especially changing environment, has affected major human *migrations*. As regards their earliest phases this research has great bearing on the fundamentals of anthropology. I have ventured to produce a theory of racial evolution and classification which is making a good many converts among professional anthropologists. In the later phases the study of modern migrations is of course linked up with the development of pioneer lands.[2]

If we now turn to the smaller and perhaps more complex groups of man known as *nations*, another set of problems arises, which may be included in the term Cultural Geography. The charting of national distributions and their relation to environment have given rise to a field of research midway between general geography and history, which the writer has found of great interest.[3]

Finally the still *smaller* examples of human association are offered for our attention in the form of cities, towns, and villages. They are closely anchored to the environment, and this relation has been engaging my interest since I first became associated with the original surveys for the projected capital of Australia, some thirty years ago. I believe that geographical technique will enable us to analyse the data connected with smaller human agglomerations, and to develop Urban Geography as an orderly department of our discipline. This should be of service to the sociologist and town planner; just as, I firmly believe, our techniques have already helped the anthropologist and historian.

Passing now to the third term in the title of my address, some explanation may seem to be necessary for introducing the determinism-possibilism controversy into this study. It is precisely because I believe that man has more "choice" of procedure as he is concerned with the *details* of geographic study, that I am making the attempt to discriminate between the two controls (environmental and human) in this approach to Urban Geography. I think that my objection to the possibilist is not because he seems often to be mainly on the lookout to see where man has exercised his powers over Nature, but because he rather tends to ignore the vastly greater importance of environmental control in most parts of the world. I have heard eminent geographers apologise for using the term "environmental control"; and this, I confess, annoys me.

I can make my point clearer perhaps by two examples drawn from lands which I have studied in detail: Australia and Antarctica. I would say that the most important geographical problem in Australia is to try to picture its population-pattern a century hence; and then to develop Australia in that

[2] *Environment, Race, and Migration*, Griffith Taylor. Chicago, 1937.

[3] *Environment and Nation*, Griffith Taylor. Chicago, 1936.

direction. The extreme possibilist says that such a project is quite visionary, because man's plans and tools will change so greatly in the interval. I have studied developments in other, older parts of the world, such as Europe and Asia, and to me it seems clear that the general population-pattern in the past has been determined almost exclusively by the environment; and so it will be in the newer lands.

In Antarctica I have no doubt that a few way-stations for aviators, and a few resorts for tourists, will develop there in the next century. These the possibilist will emphasize, as developing in spite of environment. But the determinist will say that such trivial details, in an icy area of five million square miles, are not worth mentioning in an attempt to evaluate environmental versus human control.

Now these same principles hold in other better-endowed lands. The progress of settlement in North America is in the main essentials due to environmental control; and we ought (as the chief interpreters of environment) to stress this fact. Where does the possibilist come in? As I see it, he is the short-range geographer, whereas the environmentalist takes a longer view. Nature needs centuries for her influences to work properly. In most major geographical problems there is one *best way* to do things, and of course a dozen less satisfactory ways which man can "choose." Usually man (and in this he is, in a sense, supported by the possibilist) endeavours to proceed by the long-established method of trial and error. He chooses one possible way and then another and finally adopts the one best suited to the environment. It is true that at times it is difficult to say which is the "best way," but the environmentalist is always debating the matter.

We may use the sugar industry in northeast Australia as an illustration of the difference in views. The possibilist points out that man has chosen to grow sugar in this region, even though it can be purchased for half the price in the foreign market. The long-range environmentalist would say that Australia has not yet arrived at the stage where sugar should be grown in her tropics. Australia is a pioneer country with a small population; and should at present concentrate on industries which require less costly labour. Even if he grants that the White Australia policy is worth some sacrifice, it is the geographer's duty, as I see it, to point out wherein man is departing from the *logical order* of material development.

> We see here why most economists and technologists dislike the determinist idea. They are "short-range" developers; and none the less valuable teachers because that is their province. But the geographer, in my opinion, should look much farther ahead. He should try to find the best plan among those possible. Exaggerating somewhat, I feel that man's part in the programme of a country's evolution is not unlike that of a traffic policeman. In nine-tenths of the world—but

not so definitely in the much restricted better-endowed parts of the world—a "Stop-and-Go Determinism" seems the logical ideology for the geographer. Nature determines the route, man can only control the rate of progress.[4]

Let us now return to the topics which form the main purpose of this address. Though Urban Geography is a rather new development, there is already a considerable literature on the subject. However I propose in this address to discuss certain aspects of the growth of villages, towns, and cities which I have investigated during my rather wide experience as a wandering geographer.

It is difficult to decide where the geographical observer should set his professional limits. The choice of the site of the young settlement is largely controlled by the environment. So also is its subsequent growth, excluding perhaps the pattern of the streets. The form and construction of the houses depend largely on the environment (*e.g.*, the climate) and on the materials available. But admittedly many of the aspects of a town are due to human choice, and seem to have little to do with the local environment. In these aspects this geographer has less interest. Sometimes, indeed, the city seems to develop in defiance of the environment; and this has led to waste and unnecessary expense, as I hope to show later.

Several aspects of town development have not been as fully discussed as they might be by geographers. These, as well as some more familiar problems, I hope to lay before you in somewhat the following order:

a. Some variations of towns with latitude.
b. The city made to plan, *e.g.*, Canberra.
c. The city as controlled by geological structure, *e.g.*, Sydney.
d. Stages in the development of a city, *e.g.*, Toronto.
e. The "Zones and Strata" concept as applied to towns (Port Credit & Whitby).
f. The classification of towns, and their description by formulae.
g. The bearing of this address on Determinism *versus* Possibilism.

SECTION A

SEVEN EXAMPLES OF SETTLEMENTS FROM TYPICAL LATITUDES

In this address I do not hope to do more than draw attention to the various aspects of human clusters which should be of interest in a genuine geographical approach. As a parallel I may cite the botanist, who does not need to know every unimportant detail about a plant in order to classify it, and to place it in its proper category. Or to come nearer home, Köppen has produced a workable classification of the innumerable variations in the

[4] Presidential Address to the British Geographers (B.A.A.S.), Griffith Taylor. Cambridge, 1938.

world's climates by concentrating on the main elements of the problem. We have first to answer the question, what are the main elements in the growth of a human cluster, whether in its early or its late stages?

I have therefore thought that it would be of interest to describe briefly a number of towns and settlements which I have investigated in very different parts of the world. Plans of each are illustrated, and some indications of the surrounding region and of its influence on the agglomeration is given.

In several recent memoirs I have adopted the "traverse" plan of study. Thus in the northern Sahara I described[5] the changes as one journeyed from the wet coast to the southern desert. Later, in studying the main principles of the Australian settlement in my recent book,[6] I made a similar study and investigated conditions at *equal distances* across the continent. As regards the present study dealing with towns in general, we all know that latitude is the chief variable which affects settlement. Hence the first part of this address considers seven settlements on a traverse from the Poles to the Equator approximately 10° of latitude apart, each in a different continent.

Furthermore it will be of interest to try and decide the respective importances of the environment and the human factor in these type examples. No accurate evaluation is possible, but the writer (who is somewhat of a determinist in the broader fields of racial and national distribution) is prepared to admit that the human factor becomes of increasingly greater importance as we consider smaller and smaller human agglomerations in our research.

The following table shows some of the main characters of the seven samples chosen.

	Latitude	Continent	Place	Population	Type	Raison d'être	Köppen
1	77	Antarctica	Cape Evans	25	Ice cap	(Science)	EF
2	60	Europe	Bergen	100,000	Cool temperate port	Fish, etc.	Cfb
3	57	N. America	McMurray	500	Taiga village	Fur, etc.	Dfc
4	40	Asia	Pekin	1,600,000	Oriental	Political	Dwa
5	36	Africa	Biskra	4,000	Desert	Dates; military	BWh
6	22	Australia	Urandanji	50	Semi-desert	Cattle	BShw
7	11	S. America	Santa Marta	30,000	Tropical port	Bananas	Aw'i

Since the climatic data of these clusters are of importance in the picture, I have added a hythergraph chart (Fig. 1). It shows that most of the chief environments of the world are represented. I have also inserted a "Comfort

[5] "Sea to Sahara," *Geog. Rev.*, 29 (April, 1939).

[6] *Australia: A Study of Warm Environments and Their Effect on British Settlement.* New York, 1940.

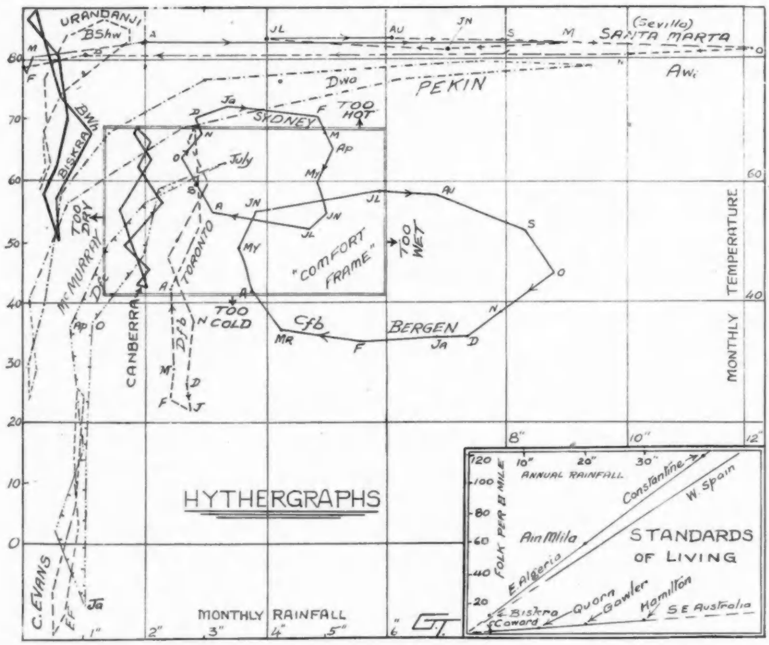


Fig. 1.—Hythergraphs of the places described in Section A., to show the widespread character of the discussion. Köppen formulae are added. The "Comfort Frame" includes the climates which are generally comfortable. Inset is a graph which compares the standards of living in three regions (Algeria, Spain, and South Australia), which all have the same environments.

Frame," which tentatively encloses the climates which most Anglo-Americans would call "comfortable." I do not however propose to dwell in any detail on climatic controls.

1. *Cape Evans, a settlement on the Antarctic ice cap*

We may learn a good deal as to the role of an adverse environment in the development of a settlement, by considering the first attempts to live in Antarctica. No doubt one of the little coal towns in Spitsbergen (such as Longyear City) would be more informative, but the sole experience of the writer has been gained on the west coast of Ross Island in latitude 77° 30′ South.

The first question one should ask about any settlement is "Why did man desire to establish himself there?" In the majority of cases the answer is

"Because he hoped to exploit Nature's resources in the vicinity." In a very remote degree this is true of the small settlements on Ross Island, of which there are three (Fig. 2). Coal or metals may yet be found in rather inac-

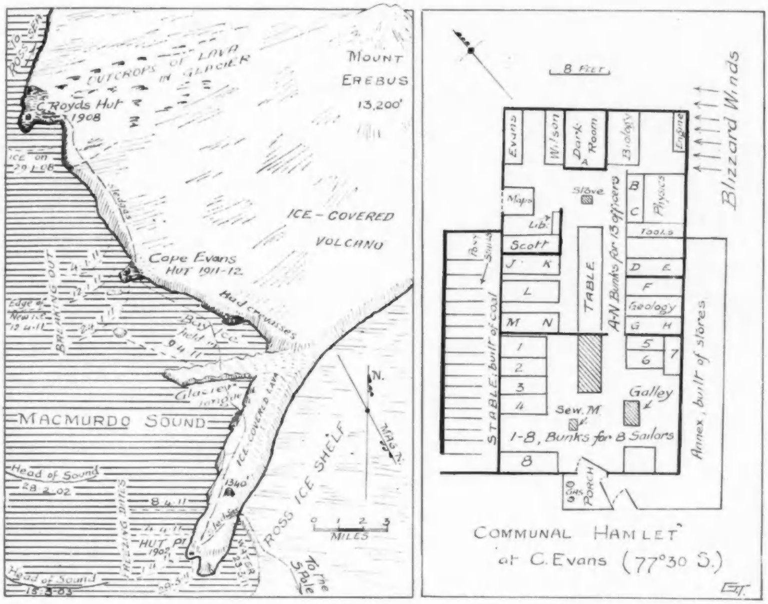


FIG. 2 (*left*).—A birds eye view of the west coast of Ross Island in the Antarctic to show the settlements made by the three expeditions (1902, 1907, and 1910) where the environment permitted. Dates of the ice freezing and breaking away are added.

FIG. 2 (*right*).—Plan of the settlement at Cape Evans, Ross Island.

cessible areas in Antarctica, though there is little prospect of immediate use.

The major attraction was that hereabouts open water is found nearest the South Pole. Hence Ross Island in the Ross Sea offered the best site for exploration, and for extending in this unique environment our knowledge of meteorology, magnetism, glacial erosion, geology, plant and animal ecology, etc.

Secondly, why was Cape Evans chosen rather than any other site? Here we have one of the best examples of environmental control known to the writer. Every explorer wished to land his stores at the most southern spot available, as *early* in the summer season as possible. Hence the huts were invariably erected at the edge of the open sea, when the boats reached Ross

Island early in January. Thus in 1902 Scott placed his hut at Hut Point; the best of all sites, since he could here easily reach the southern Ice Shelf (Photo 1). In 1908 Shackleton's ship could not sail farther south than Cape

PHOTO 1.—The 1902 Hut built by Captain Scott, about 14 miles south of the 1910 Hut. Behind is the low peak of lava known as Observation Hill (720 feet).

PHOTO 2.—The 1910 Hut built by Captain Scott on MacMurdo Sound. Notice the Annex on the right, built of food cases. Behind is the lava scarp called the Ramp, and the volcano of Erebus (13,000 ft.).

Royds, where he was isolated from the mainland by open water, or by the crevasses of Erebus during the best sledging months.

On Scott's second expedition, in which the writer was senior geologist, we found thick bay-ice south of Cape Evans on the 4th of January. This fixed the site of the hut at Cape Evans (Photo 2). The southern parties were able to reach the Ross Ice Shelf as late as the 24th of January, but in a few days open water separated the hut from the Ice Shelf. It is of interest that our sledging parties returning from the south were unable to return to our own hut at Cape Evans until the 13th of April. In the meantime we lived in the communal settlement at Hut Point (Photo 1). Two years later two men were drowned on this short crossing of 14 miles, because they tried to traverse the sea ice to Cape Evans before the new ice was thick enough. In the map (Fig. 2) I have added actual dates in 1911 when the sea froze near Hut Point; and when the ice broke away near Cape Evans.

Such then was the umland of Cape Evans. To the east extended uninterrupted ice slopes to the summit of Erebus at 13,000 feet. In places fields of crevasses prevented any crossing of the land ice; and of course the level sea-ice was far preferable for sledging, except in the season when it was liable to break away under one (in the summer).

The third question to answer is "What kind of a settlement developed on the chosen site?" I have ventured to talk of Cape Evans as a "communal hamlet"; since it reminds one of the similar settlements in Jugoslavia in the late middle ages. (Still better would the term apply to the more complex hamlet at Little America.) The main hut (Fig. 2) had a floor area of 50 feet by 25 feet, and a simple roof with a central ridge. Three small windows, permanently shut and with doubled panes, admitted sufficient light in the summer, while in the long winter an acetylene plant in the porch gave us light.

Of considerable interest were the precautions to keep out the cold. In addition to five layers of wood and packing forming the walls, the hut was protected by side-sheds. These two annexes are clearly shown in the plan (Fig. 2). On the west the stables were built of compressed coal while on the east an enclosed verandah was built of boxes of food, etc. To serve the varied needs of the 25 settlers there were smaller buildings in the vicinity; such as the magnetic hut and the ice grottoes for storing food (and for pendulum work). There was also a great store of compressed chaff for the support of the ponies; while the dog kennels formed a lively *faubourg* to the south.

At the end of the second winter the southeast blizzards had covered everything, so that the hut was almost invisible. But life inside the hut, with the temperature held at 45°, might be summarised in the phrase "dark

and dirty, but comfortable." Outside the average temperature for July was around $-20°$ F.

If we use the analogy of living organisms in connection with this study of town development, then the hamlet just considered may be likened to an extremely simple animal consisting of only one cell. All functions are carried on in this cell, and no "zones" are present. It represents the simplest of human clusters, and is clearly in the infantile stage of town development.

A few further notes on the environment may be added. The normal sledging season extends from about September 20th to March 20th. In these latitudes ($77\frac{1}{2}°$ S.) the sun vanished about April 22nd and returned on August 22nd. However the great cold and the almost constant blizzards made March and September very unpleasant for such sledging as had to be done. No vegetation (except rare moss and lichen) is found in the whole continent, so that no animals can live on the land. Practically all the food (except seal meat) had to be brought from civilised lands.

The density of human settlement under these conditions is too low to be charted. It may be noted that the nearest similar temporary settlement was the hut 400 miles north at Cape Adare; while Framheim (Little America) was about the same distance to the east. As far as the Antarctic continent is concerned, the geographer can say that the environment is supreme. Man (in the form of explorers and scientists) may *choose* to inhabit certain minute dots therein temporarily and at great expense, but the writer sees no argument in favour of Possibilism in our first example.

2. *Bergen, a large town in the cool temperate portion of Europe*

As noted earlier, our examples are to be taken at average intervals of 10 degrees of latitude. Hence our second example is in a cool temperate climate, but is not typical thereof; since the coast of Norway has the highest winter anomaly in the world. However it is an extremely interesting town, for a variety of reasons. Owing to its position on the northwest of Europe it experiences almost constant, warm, moist, southwest winds. These produce a typical marine climate (**Cfb,** as shown in Fig. 1), with a heavy rainfall and a very mild winter.

In addition to the unusual climate, Bergen has an unusual topography. Owing to the epeirogenic uplift of the Caledonian Folds in Norway during late Tertiary times, the hinterland of Bergen is a plateau of about 4000 feet elevation. The Caledonian folding took the form of a series of parallel arcs, whose anatomy is clearly visible in the topography today, for the uplift consisted of alternating strips of hard granitic material and of softer Silurian schists. Erosion since the uplift, whether by water or ice, has removed the softer schists much more quickly than the harder eruptive rocks, and these

"Bergen Arcs" (crossed by what seem to be tension cracks) account for the regular valleys and gulfs which have in large part determined the site of Bergen (See the inset in Fig. 3). Thus By, Sor, Kross, and Fuse Fiords

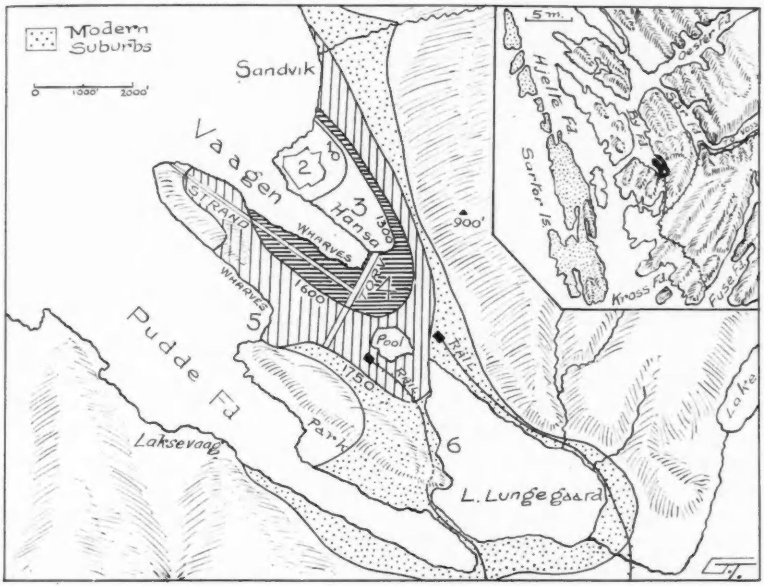


FIG. 3.—Plan of the town of Bergen (Lat. 60° N.) in Norway, to show the control of the growth of the city by the topography. Based on H. Slanar. In the inset the site of Bergen (black) at the centre of the fold-arcs and fiords is charted.

are hollows eroded in the arcs of soft schist; while Oester and Voss Fiords are perhaps in part cross-graben due to tension.

Let us now answer our standard questions. "Why did folks settle at Bergen in the first place?" We may safely assume that it was but one of numerous sites used by the early Viking seamen. In the soft silts at the north side of the By Fiord, they dragged their boats ashore near the Sandvik of today (Fig. 3). In the early days Lungegaard Lake was connected to Vaagen Bay; while two morainic ridges separated Vaagen from Pudde Fiord. The town was founded near the present Bergenhus (No. 2 in the plan) about 1075; and in later times several forts were built hereabouts to protect the harbour.

The Danish King Canute controlled Britain, Denmark, and Norway; and he placed his capital at Bergen; which lay midway between Edinborough, Opslo (Oslo), and Nidaros (Trondheim). The name Bergen is derived

from Berg-vin, *i.e.*, mountain meadows, and refers to the abundant grass on the slopes of the By Fiord. During the 12th century English traders were gradually replaced by Germans belonging to the Hanseatic League. During the next few centuries they built large warehouses all along the north side of the Vaagen, which is called Tydske-brygge (*i.e.*, Deutsch Quay) to this day. About 1600 the power of the Hansa declined, and trade had all passed into Norwegian hands by 1750.

Before examining further the growth of Bergen it may be well to point out that it is the most northern city containing 100,000 people. This is the more remarkable since it is not a capital city, having been replaced by Oslo several centuries ago. (Helsinki, Stockholm, and Leningrad are all further south.) Nor has it any fertile hinterland, as is obvious from the inset map. We may safely say that its advantageous position in respect to the fishing grounds, and to the trade of the North Sea and the Atlantic Ocean, led to its very considerable expansion. As the map shows, it is protected from storms by the "skerry guard" of the low Sartor Isles. Areas of farm-land on the floors of the numerous glacier-cut troughs are relatively large to the south-east of Bergen. Especially after the Bergen-Oslo Railway was built in 1900 did the city grow vigorously. Fish at first, and later ship-building and an entrepot trade in grain, wool, and petrol, account for Bergen's prosperity. It is still the chief trading port for Norway.

Reference to the main map in Figure 3 shows that Bergen was confined to the east side of Vaagen until 1300. This was the Hanseatic centre, perhaps at its maximum about 1500. Then the swampy land at the head of Vaagen was gradually covered with streets and houses. The present shopping and office centre is along the Torv (market) and Strand streets. Here also is one of the largest fish markets in the world. By 1750 the area between Vaagen and Lungegaard was all occupied by buildings (Photo 3).

Bergen has been the scene of many fires, one of the worst occurring in the district around the Pool in 1916, but this area has all been covered with large stone buildings since that date. Modern suburbs have spread round Pudde Fiord and Lungegaard. Various factories, mostly connected with ships or fish, have sprung up in outlying areas like Laksevaag or Sandvik. The steep sides of the hills, Floi-Fell (900 feet) on the east, and Lovstaken (1500 feet) on the southwest, have prevented the city from spreading far from the original site around Vaagen.

We can clearly see the part played by topography and climate in the growth of a town as large as Bergen in this high latitude; the same as that of South Greenland, north Labrador and the Bering Sea. Yet many cultural factors are of course present. Bergen was an early centre of religious and political power, and these are man-made factors. Water-power, fisheries, tourist trade, and railways depend partly on physical, partly on cultural

PHOTO 3.—The Wharf at Bergen, once occupied by the Hansa merchants. The harbour (Vaagen) lies to the left. (Courtesy of Robert S. Platt.)

conditions. A determinist will stress the former and say that water-power depends primarily on topography and rainfall, fisheries depend on the temperature and food conditions in the sea. Tourism flourishes where Nature has displayed her choicest scenery. Railways must go where the natural corridors are easiest. Man can *choose* one of an infinite number of ways of exploiting a country; but it seems to the writer that our "chooser" rather resembles the so-called "yes-man." If he is to prosper, he does well to choose what Dame Nature the Dictator indicates is the best for him!!

My visit to Bergen in 1931 was too short for me to make a functional survey of the town; and so far as I know this is not available. Many of the historic data in my main map are based on H. Slanar (*Proc. Geog. Soc.*, Vienna, 1918). It is obvious that the city exhibits the usual plan; with the business centre near the Torv, and with more or less concentric zones of offices, apartments, and villas to the south. These zones are somewhat horseshoe shaped (rather than circular), in accord with the unusually hilly topography of the site.

3. *McMurray, a fur-trading river port in North America*

In 1778 Peter Pond explored the region north of Lake Athabasca, and about 1790 the Northwest Company established a fur-trading station at McMurray on the Athabasca River (Fig. 4 at A). It was situated on the main corridor of canoe-travel from the Great Lakes to the Mackenzie River. Canoes reached Lake Winnipeg *via* the Lake of the Woods. Thence they

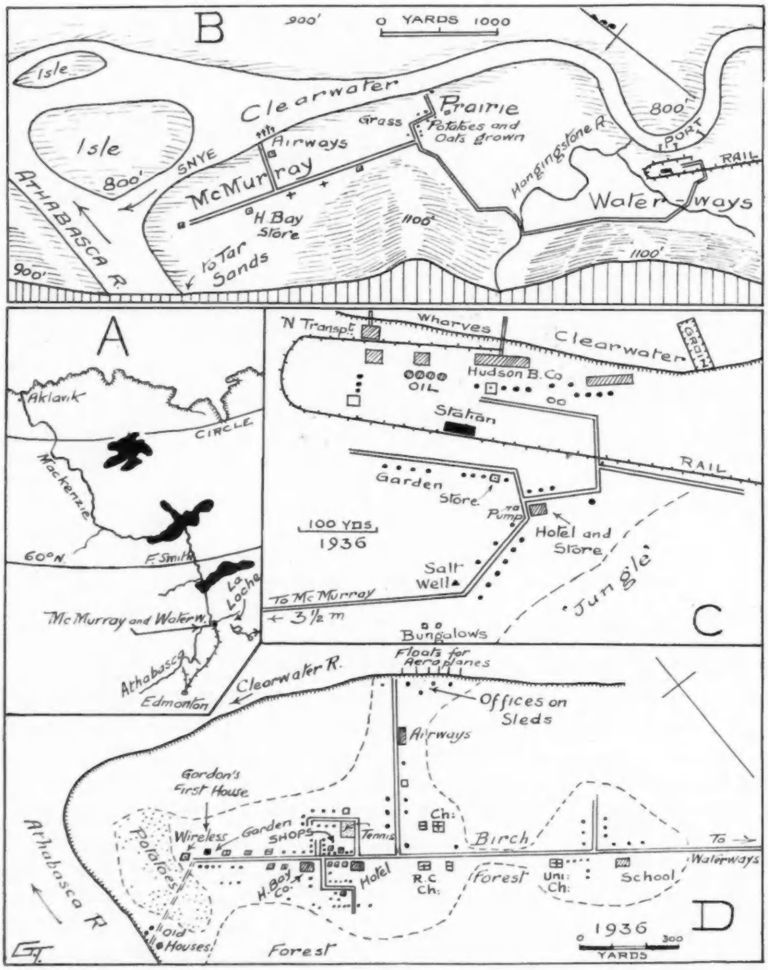


FIG. 4.—Settlement conditions in the Taiga of north Canada. At **A** is a map of the Mackenzie Basin, showing McMurray and Waterways as well as the La Loche Portage. At **B** is a block diagram of the twin towns of McMurray and Waterways. At **C** is a detailed plan of the "infantile" settlement of Waterways. At **D** the same for McMurray.

paddled north to Cumberland House on the Saskatchewan, where they entered the Sturgeon River. At the head of this stream the Frog Portage led to the Churchill River which rises in La Loche lake. At the north end of

the latter was the famous La Loche Portage where Methye Fort was built (Fig. 4). A rough wagon road of $12\frac{1}{2}$ miles was constructed here in 1875, so that heavy goods could be placed on the Clearwater River.

McMurray, the settlement under discussion, grew up 40 miles west of the portage at the junction of the Clearwater with the mighty Athabasca River. The waters of the latter, after passing through Lake Athabasca and Great Slave Lake, reach the Mackenzie River. The first steamer traversed the Mackenzie from Fort Smith Rapids in 1887, while in 1920 the railway from Edmonton reached Waterways on the Clearwater.

Today the train traverses the Taiga north of Edmonton once a week, and I made my survey in July, 1936. At Lac La Biche (132 miles north) is the last of the farming country, though small patches of crops are grown right to the Arctic Circle. The chief inhabitants north of Lac La Biche are Cree Indians, engaged in trapping and fishing. The little towns, marked hereabouts on the map, usually contain fewer than half a dozen houses. It is therefore somewhat of a surprise to find that there are *two* towns at the end of the railway. These are Waterways and McMurray (Fig. 4 at B). Possibly it was intended to carry the railway beyond Waterways to the older settlement of McMurray. But deep water is available in the Clearwater; while rather high prices were demanded for the necessary lands at McMurray, so that there seems no likelihood of the railway being extended at present over the intervening three miles. Waterways controls the railway traffic, and here the loading of the steamers and scows for the northern country takes place. McMurray is still the centre for the local fur-trade, and for the growing air-borne traffic to the mining fields of the north.

There is little doubt in the writer's mind that this "twin settlement" is destined to grow rapidly in the next few decades. Hence it seems of importance to learn just how the town has progressed in the years since the railway arrived. One must confess that Waterways shows no evidence of any design whatever (Fig. 4 at C). The railway curves round the station in a loop which serves the huge storage sheds of the Hudson Bay and Northern Transport Companies. The offices of the Companies are naturally close to these sheds. A large oil depot is between the two (Photo 6). Five small steamer-scow units link Waterways to the portage at Fort Smith. The river is open from mid-May to mid-October.

There are a dozen wooden houses, mostly little more than frame shacks, scattered in the vicinity. A few hundred yards from the station is the combined hotel and store—a more elaborate two-storey building—which is the natural centre for Waterways. Water for the hotel is obtained from the village pump across the street. One other smaller store is nearby. There was (in 1936) no church or school in Waterways; indeed about a score of wooden bungalows and shacks were all the other buildings in the place.

Perhaps one reason for the lack of plan is the possibility of floods. In the spring and autumn the northern parts of the rivers are frozen, while the southern waters are still pouring their supply northwards. Hence widespread floods occur at times, which drown the houses of Waterways in several feet of water. Back of the settlement (Fig. 4) are rounded hills rising 300 feet above the river. These are clothed in a regular jungle of conifers and aspens. Natural clearings with considerable areas of pasture occur in places, and one such grassy meadow was grazed by the cattle of the early fur traders (about one mile east of McMurray) in the district now called Prairie (Fig. 4 at B).

For a settlement 140 years old McMurray is not very imposing. There is the straight main street about a mile long, which runs west to the junction of the two rivers (Fig. 4 at D). All the houses are shown in this large-scale map; and they are almost all frame houses and one storey high, though the shops often have a false two-storey front. However the Hudson Bay Store and the chief hotel are more imposing buildings, and most of them were neat and freshly painted. Indeed the school and churches are quite attractive buildings (Photo 4).

PHOTO 4.—The main street of McMurray (Alberta) looking to the west. The large building on the left is the Hotel, the Hudson Bay Store is four buildings to the west.

In addition to the big Company store there were three other stores, three cafés, two butchers, two barbers, and a drug store. The Bank, Post Office, and Dance Hall are in the shopping block. At the west end near the big river is the Wireless Station, while a few fur-dealers indicated the main local product. In the detailed map an area of several acres is shown as growing potatoes. These belonged to a Japanese farmer, and seemed to be flourishing.

The air-transport offices are on a branch of the Clearwater called the Snye (Fig. 4 at B). I was much interested to find that their haphazard arrangement along the bank of the river was due to each office being mounted on runners like a sled, so that during the flood periods in spring and autumn, they could be drawn to higher land to the south (Photo 5). This is a form

PHOTO 5.—The offices of the Air Transport on the Clearwater River near McMurray. These offices are mounted on runners, so that they can be dragged to higher ground in the spring and fall floods.

of transhumance new in my experience. At the time of my visit the three air companies were shuttling ten planes to and from the northern mining fields, notably those near Yellowknife. Finally, about a mile from McMurray in the high shale cliffs of the Athabasca are to be found thick layers of Tar-sands, which in the future will be used as sources of petroleum.

McMurray is I believe the sole town north of the Alberta-Saskatchewan farm lands. But Churchill and some of the Yukon towns are doubtless larger. Howbeit it has few rivals as a high-latitude town in North America. It was founded about the same year as Toronto, but while the latter has grown to a city of 800,000, McMurray has a population of about 600 in summer and 300 in winter. Its satellite Waterways supports about 300 folk in summer, but the population falls to about 30 in winter. Man could "choose" to go there in his thousands, but for environmental reasons he prefers Toronto and Montreal!

McMurray however is large enough to show the beginnings of functional zones. The oldest houses are at the river end of the main street, but the business centre is the block between the hotel and the Hudson Bay Store.

The churches and schools have been built in clearings cut out of the birch forest to the east. There is not yet any differentiation into first and second class residence zones, so that it may be classed in what later is called the juvenile stage (page 49). Waterways is too immature to show any plan, and is in the infantile stage (Photo 6).

PHOTO 6.—The oil tanks at Waterways. The frame building is typical of this pioneer settlement, and was transferred here from a former rail terminus.

The site of McMurray is clearly determined by the junction of the two streams of canoe traffic via the Athabasca and La Loche. The steamer port was placed here because of the rapids in the Athabasca just above McMurray. The next similar steamer port is at Fort Smith Rapids, about 250 miles to the north. But the railway is unlikely to be extended to Fort Smith since air traffic is already reducing the importance of steamers and railways in the empty northlands. Apart from its junction-position below the rapids, McMurray seems to offer no advantage over a dozen other sites in northern central Canada. But this definite environmental factor has given it a small lead, enough to make it the railway terminus and air-port. Cannot we agree again that man has "chosen," out of many "possible" sites, that which Nature had already marked out as the best?

4. *Pekin, a delta city in the temperate zone of Asia*

Pekin offers a fair example of a large city which has developed under temperate conditions in a gigantic deltaic plain. It is larger, older, and much more complex in its evolution than any of the other examples, so that it represents the other extreme in our study from the settlement at Cape Evans.

Yet we must try to answer our fundamental questions just the same. It is difficult to point to any environmental factor which has led to Pekin's dominance over most of the towns in the deltaic deposits of the Hoang-Ho. These cover an area of about 80,000 square miles; for though the plain extends south to Shanghai the southern portion (containing this city and Nanking) does not derive from the Hoang-Ho.

One would have expected the chief northern city to have developed either in the centre of the plain, or near the main river, or possibly at a good harbour on the coast. Pekin fulfils none of these conditions. In early historic days the capital of China was undoubtedly in Shensi. About the time of Christ it was moved east to Honan, and about A.D. 317 to the coastal province of Kiang-su. For a time around 960 it was placed at Kaifeng, which has a central position on the great river. However in the 12th century the Kin tribes of the north made Chung-tu their capital; and this town occupies the site later known as the Chinese section of Pekin (Fig. 5). The

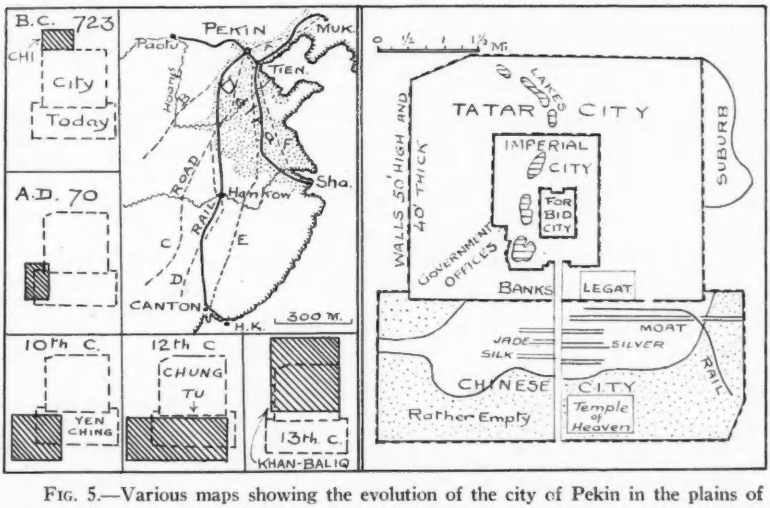


FIG. 5.—Various maps showing the evolution of the city of Pekin in the plains of north China. At the left is shown the evolution of the city (from the *Encyclopedia Sinica*). A small map is inserted to show the deltaic plain, and the roads and railways to Pekin. A generalized map of the "concentric cities" of Pekin is given on the right.

Mongol conquests resulted in Kublai Khan, about 1280, building a new capital (Khan-baliq) immediately to the north of the older Kin city of Chung-tu. This was the capital described by Marco Polo. Towards the end of the 14th century Nanking was made the capital, but from 1403 to 1911 Pekin continued to be the capital city of China.

It seems clear that a considerable "human" element is involved in the choice of the site of Pekin. In early days necromancers ascribed to the site a peculiarly fortunate character. No doubt the chief factor was political, since here the Chinese ruler could keep an eye on the marauding Mongols; while later the Mongol conquerors preferred to rule the Chinese from a city not too far away from their own native land.

The traveller reaches Pekin across a vast sandy plain, and no river or canal links Pekin to the outer world. The port, before the railway era, was a little town on the Pei Ho River to the east. Today Tientsin is the chief entrepot for the capital, and the writer reached it by this route in November, 1926. From a distance, the walls of Pekin give it the appearance of a gigantic box, with sides about five miles square—which has been flung down upon the plain. The present population is about 1,600,000, but about half the Chinese City of today is only sparsely occupied by houses, the southern portion containing many temple gardens and large open spaces. Ancient moats surround both portions of the city, while from the walls the numerous trees in the palace gardens and temples make a picturesque and unusual scene in this bare and level part of north China (Photo 7).

PHOTO 7.—A view of the Great Wall and one of the typical gates on the southern side of the Tatar City of Pekin (Peiping).

Turning to actual plan of this Oriental city, today its arrangement is unique. The Chinese city consists of the usual narrow crowded streets of an Oriental settlement, flanked by innumerable small shops which cater largely to the tourist trade (as some of the street names suggest). The walls

round this quarter were built in 1453, and are not quite so high as those around the Tatar city, which are 50 feet high and 40 feet thick. In the latter the streets are broader and the buildings larger and much more imposing. The Foreign Legations occupy the southeast portion of the Tatar city between the Hata Men and Chien Men Gates. They are enclosed in high private walls which enabled them to withstand the Boxer rebels in 1900.

A stream formerly crossed the Tatar city from North to South; and this has given rise to a number of ornamental lakes, which beautify the palace grounds of the Imperial City. The latter is enclosed in the centre of the Tatar city, and in turn it protects the Forbidden City where the Emperors spent most of their lives. In the northern part of the Imperial City is a small hill 200 feet high called Coal Hill. It is crowned by several small temples, and contrasts with the surrounding plains; but this "eminence" is undoubtedly artificial in origin.

The Tatar City is covered with buildings, streets and palaces; and though many Manchus still live here, the majority of the people are now Chinese. It is difficult to chart functional zones for this city, for the ancient and modern plans are somewhat at variance. Originally the emperor's palaces and household occupied the Forbidden City. The government officials lived in the Imperial City, the ruling caste of Manchus in the Tatar City, while the subject groups of Chinese were in the adjacent but separate Chinese City. Today the palaces are largely museums, while the government offices are mostly scattered through the southern half of the Tatar City, though some are still in the Imperial City. Probably the huge walls will be levelled in the near future, and the space converted into wide boulevards and gardens. It may be noted that though large areas of the Chinese City are empty, yet there are a few small "suburbs" outside the walls, especially to the east of the Tatar City.

A glance at the map of China shows that there is no other large city in North China near to Pekin, except Tientsin. The magical and political factors (briefly referred to earlier) led to the city's birth, perhaps as far back as 723 B.C. At this time "Chi" was the capital of the Yen kingdom, according to the *Encyclopedia Sinica* (Fig. 5). Given this start, no other city seems to have arisen to compete with it, though other sites such as Kaifeng would seem to have more to recommend them. In process of time the main roads inevitably led to Pekin, and six of these Imperial Roads (A to F) are shown in Figure 5. Later the four main railways also radiated from Pekin, respectively to Mukden, Paotu, Canton and Shanghai.

In latitude and origin Pekin reminds one of Madrid, but the climate is rather different. There is a hot, wet summer and a very cold, dry winter.

Owing to its eastern position in the huge land-mass of Asia Pekin has a rather extreme climate, as is clearly shown by the hythergraph in Figure 1. The long extension of the graph to the right (in summer) indicates a marked rainy season, so that the graph for Pekin is fairly typical of Monsoon conditions.

The present plan of Pekin is essentially oriental and medieval. But an enclave of occidental culture is being incorporated in it, especially in the southern part of the Tatar City. We may perhaps compare this enclave to the neotechnic sections developing in certain parts of an occidental city. (I return to this concept later when discussing the plans and growth of Trento.) The palaces clearly form the nucleus of Pekin, even though today no emperor lives there. Around them is an administrative zone, and beyond that the upper-class town of the Tatar City. Smaller shops and slum areas are rather characteristic of the separate southern quarter called the Chinese City. I shall not try later on to give a formula for Pekin; but may remark that we are here confronted with an example of city structure as complex as some of those composite *minerals,* whose chemistry almost defies the formula-maker. Luckily few towns are so complex.

It must be admitted that the choice of the site of Pekin is not due to any marked environmental factors. Obviously in such a rich agricultural region as the Hoang-Ho delta, some large distributing centres were bound to develop, but they are less characteristic of a primitive oriental culture than of a modern industrial occidental culture. We may perhaps grant that Pekin—situated in a vast region of *uniform* environment—is a good example to suggest that the possibilist theory does, under such conditions, explain the facts of geographical distribution.

5. *Biskra, a desert town in the Mediterranean region*

In 1938 I was able to carry out a life-long plan to compare the Sahara Desert with the arid areas of Australia. While the environments are alike, there is naturally very little resemblance in the human settlements. This may, at first sight, be taken as a triumph for the Possibilist Party. I am of the opinion, however, that the dissimilarities in the two types of settlement are merely due to the different stages of development obtaining in Algeria and Australia.

Let us compare Coward Springs in Australia (450 miles northwest of Adelaide) with Biskra. Both lie on the edge of the desert, and have a winter rainfall of 4 inches. The covering of sparse but regular vegetation in each case is similar in pattern though not in genera. Both, curiously enough, are situated on the edges of artesian basins. Both have railways, which have been running for many years, in the case of Coward Springs

since 1890. When I visited Coward Springs in 1919 it was the chief settlement on the railway for 50 miles in either direction. A small date oasis had been planted here many years before, yet the "town" contained only four houses, two of which were empty. (Given an *excellent* environment, such as at Chicago, a settlement might add a million to its population in the same period.)

Let us now see what has happened in the Sahara with a far lower standard of living and a far greater population pressure. In spite of an equally unfavourable environment, Biskra is an apparently flourishing town with about 10,000 inhabitants, of whom 2000 are French (Fig. 6). It is

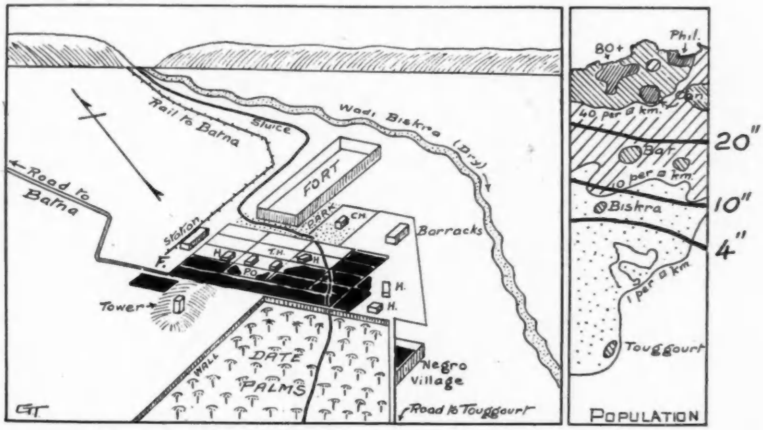


FIG. 6 (*left*).—Site-view of Biskra looking to the northeast. The town extends half a mile southeast of the station. The church, chief hotels, post office and town hall are indicated by initials. The chief Arab quarters are black. F. is a factory site.

FIG. 6 (*right*).—Sketch map showing population density per square kilometre. Heavy lines are isohyets. (Both maps from *Geog. Rev.*, April, 1939; isohyets added.)

supported primarily by the date oases, but also by the French military station, and to a lesser degree it acts as a caravan terminus and (in winter) as a tourist resort. My own visit was made in midsummer; when, it can readily be understood, our appearance was hailed as manna in the wilderness by the hordes of touts and beggars.

Biskra lies 25 miles south of the striking gateway through the Aures Mountains called El Kantara. Even in Roman times there were garrisons at El Kantara and to the south at Veskara (*i.e.*, Biskra). Hence the town has had a long and eventful history.

The little river Tilatou runs south from the interior plateau to the marginal range, and thence through the gorge at El Kantara to the Sahara. At this settlement wheat is grown on little hill-fans just north of the gorge; while south of it in or near the stream-bed is a large date oasis which supports 6000 Arabs. From El Kantara the water (in winter) flows south for miles into the veritable desert and reaches Biskra (Photo 8). Thence

PHOTO 8.—The palm Oasis of Biskra in the Sahara, showing the water from the Atlas Mountains which irrigates the Date Palms.

it flows south, and, at times, reaches the salt playa called Shott Melrir, which is below sea level. Small mesas diversify the desert just north of Biskra. Oleanders grow along the dry bed of the stream with occasional patches of date palms. The vegetation is in tussocks with usually low tamarisk clumps or masses of reeds.[7]

[7] "Sea to Sahara," Griffith Taylor. *Geog. Rev.*, 29 (April, 1939).

There is little of the pre-French town remaining at Biskra. A rectangular arrangement of streets, with the main axis running N.W.-S.E., extends for half a mile between the station and the group of large hotels in the southeast. The centre of the town contains the Town Hall and Post Office, while barracks are to be found near the wadi to the east. But the most noteworthy feature of the town is the large Fort (400 by 200 yards) which defends the town on the north. This is surrounded by stout brick walls about 20 feet high, and guarded by towers with slots for rifles. Inside this wall are the military offices, hospitals, as well as many small houses for officers, etc. (Photo 9). At the extreme southeast corner of Biskra is

PHOTO 9.—The walls of Biskra, with a flock of goats brought in from the environs. A tower of the French Fort appears in the background.

the small "negro village," though the dwellers seemed to be of Arab rather than negro origin. A large and roughly circular area of date plantations extends for nearly 2 miles to the south of the town.

The houses are built of brick or of irregular stones covered with stucco and painted white. In the town both the French and Arab quarters contain two-storey houses, but in the lower-class houses in the quarter south of the main town, the characteristic high Arab walls enclosed small yards on to which various flat-roofed rooms opened. A crowded open market, as well as a mosque, are typical buildings in the Arab portion of the town.

Biskra is the terminus of a light railway which runs south to Touggourt, and collects the date harvest for export from the Sahara (Fig. 6). Possi-

bly foreigners imagine that many such railways may run south into the rainless desert in the future. But it is the artesian water which makes possible the string of oases to the south of Biskra; and so far as I know there is no other locality in the French Sahara so well endowed. In prehistoric times the rains on the Ahaggar Plateau gave rise to the large river Igharghar, which flowed north to Touggourt. Probably today some of the scanty waters flow far to the north along relatively deep-seated permeable beds, and replenish the artesian basin under Touggourt. No doubt waters from the Atlas mountains also reach this basin.

The city-plan of Biskra shows us a fort in the north with a park belt and a zone of offices just to the south. The latter lies in the centre of a belt of better-class French houses. Still farther south is another zone of second-class houses, while yet south again is a belt of smaller oriental Arab houses.

How does Biskra fit into our determinist-possibilist debate? When we think of the enormous length of the northern border of the desert, which extends about 2500 miles from the Wadi Draa to Suez in the east, it is clear that only a few districts are as favoured as Biskra. There is only one bygone Igharghar River, and probably no equal to the Touggourt artesian area. Figuig and Laghouat are similar desert outposts, but only the former is served by a desert railway. Hence I should make use of our Biskra example as follows:

Given desert conditions such as obtain in the Sahara, there are only a very few sites where the ameliorating factors have justified modern enterprise in developing the district as the French have developed Biskra. Even the military site was strictly determined by the water and the traffic conditions. We may note that these were also in operation in Roman times, centuries before the French took over Algeria. As usual I see Nature (*i.e.,* the environment) acting as the dictator far more than man in the settlement problem under these difficult conditions.

The possibilist, it seems to me, puts the cart before the horse. He would say "Ah, but the vital trade in dates owes much to the artesian bores and to the desert railway; and surely these are due to human energy?" The determinist replies "Man can put down bores and build railways anywhere in the Sahara; but in the vast majority of cases he takes very good care to do so only where Nature has provided the conditions to make such expenditure worth while."

In such exploitation Nature determines the route of development, man only determines its rate. To return to the parallel with Coward Springs in Australia. I see no sign of man utilising this southern region yet. But when population pressure has increased to something like that present in Algeria, then we shall find man in Australia using the methods of develop-

ment which Nature has driven man to use in the same environment at Biskra.

We may illustrate this phenomenon of population-pressure by comparing the population densities in three regions, each of which has much the same environment. They are western Spain, Algeria and southern Australia. All have a Mediterranean climate with similar and pleasant temperature conditions on the whole. In all three regions the rainfall diminishes in the interior. It is obvious that crop-densities (and therefore populations) depend primarily on rainfall.

In the graph inset in Figure 1 the relation is expressed approximately by a straight line for each of these regions. Spain and Algeria exhibit very similar conditions; and, to the writer, this indicates that the population-pressure is about the same in each. Southern Australia shows a much lower density of population for the same rainfall. At a rough approximation, this seems to indicate that the population pressure in Spain and Algeria is about eight times as great as in southern Australia. The natural result is that standards of living are far higher in Australia. But it is entirely probable that population pressure in Australia will increase considerably as time goes on. Later on, the graph-line for Australia will climb to a position much closer to those for Spain and Algeria. The difference is not really due to human choice, but to the *immature* character of Australian settlement.

6. *Urandanji, a semi-desert hamlet in the east of tropical Australia*

For my sixth sample I have chosen a tiny village on the pioneer fringe of Australia, of which I made a sketch survey when I was investigating the rival trans-continental railways in 1922. Urandanji, tiny as it is, appears on most maps of Australia for it is the sole settlement in that part of Queensland. Camooweal is 120 miles north, while Boulia is the same distance to the south. Somewhat nearer are the mines at Dajarra and Duchess on the railway to Townsville. The striking feature about Urandanji's position however is that there is no town to the *westward for 1200 miles*, until one reaches Marble Bar not far from the Indian Ocean. It is true that there are a few large cattle ranches near Barrow Creek (Fig. 7); but hardly a score of white folk inhabit these areas of sparse pastoral occupation. They are indicated as white patches in the uninhabited portions of tropical Australia, which are shown by close ruling.

What sort of a settlement has grown up in this pioneer region of Australia during the fifty years or so of its pastoral development? With a total rainfall of only 11.4 inches, and an average temperature of 74° F., one could not expect much of a human agglomeration, especially as the evaporation is not far from 120 inches a year.

One day in August 1922 we motored west across the rather rough landscape between the railway at Duchess and Urandanji. We passed two ranches in which the usual bare iron buildings (raised on wooden piles to combat white ants) rather repel the traveller who comes from more favoured districts. Some 20 miles from Duchess we climbed up a stony pass amid giant ant-nests and clumps of desert spinifex grass (*Triodia*). West of this range the rock outcrops changed from sandstone to shale, with an immediate improvement in the grazing capacity. In these plains the soil is often a red gravelly clay and carries sparse Mitchell Grass. Wild bustards and large kangaroos were occasionally seen.

The little township lies 150 miles on the hot side of the Tropic of Capricorn. It consisted (in 1922) of an hotel, two stores, the post office and a few other houses disposed on each side of the broad main street. (Fig. 7). In all cases the walls are made of "weatherboard" *i.e.*, planks cut from hard eucalypts (with a wedge section) and nailed in a

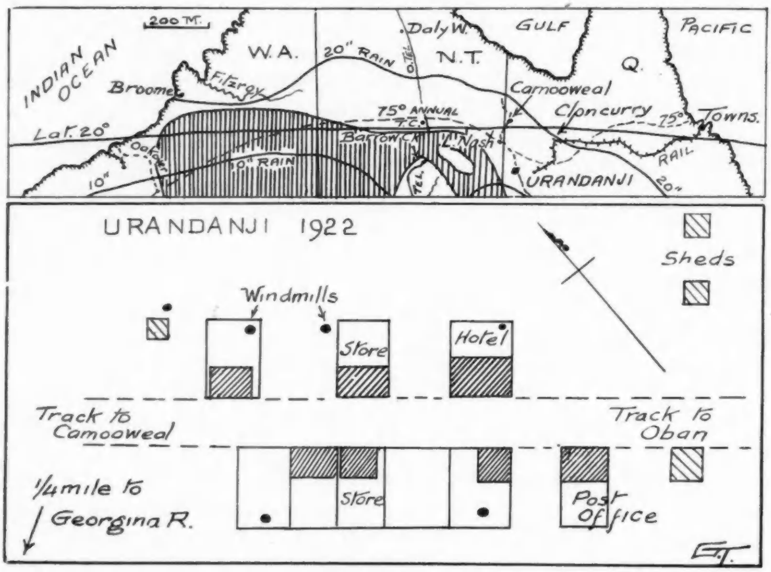


FIG. 7 (*top*).—A map of tropical Australia to show the position of Urandanji, just to the east of the widest expanse of empty land in Australia. Ruled areas are desert, and isotherms and isohyets are inserted.

FIG. 7 (*bottom*).—A sketch survey of the little settlement of Urandanji on the main stock-route from Camooweal to Marree.

horizontal position. Iron roofs and verandahs are universal. The most prominent features were half a dozen iron windmills, which pump up river soakage from wells some 50 feet deep.

Though no large trees grow in the township, yet there are some fine hedges of acacia; and two or three of the gardens contained beautiful rose-trees. The Georgina River rises north of Camooweal, and after a course of 200 miles passes close to Urandanji. In times of flood the river may be several miles wide, but on my visit hardly any rain had fallen for the last six months (Photo 10). However there was a fine pool in the river, about half a mile long, near the township, which indeed owed its position partly to this vital factor, the river.

PHOTO 10.—The Georgina River which flows through Urandanji in the west of Queensland. The rainfall is about 10 inches here, but large waterholes persist for many months in some parts of the river.

Further up the river in Northern Territory is Lake Nash (Fig. 7). It is the only permanent water available to the wild blacks in a dry season, and accordingly they tend to congregate here each November. A large cattle station has been established at Lake Nash, to the west of which is the Arunta Desert.

We may sum up by stating that under the environmental conditions cited, with cattle ranches about 20 miles apart, a little town such as Urandanji has developed about half way between Camooweal and Boulia, *i.e.*, 120 miles from either. The hamlet is on the great stock-route of cattle travelling from Northern Territory and Camooweal to the South Australian Railway at Marree. Some day Urandanji may be on or

close to the logical transcontinental railway, which will link Darwin to the populous country in the southeast of the continent.

It is worth noting that the Urandanji district is a homoclime of much of the Darfur, Chad, and Middle Niger regions in Africa. These receive about 11 inches of summer rain, and this is sufficient to enable hundreds of small towns to develop in Africa. The average population density in the African belt is about 6 per square mile. In Australia it is about one-eighth of a person per square mile for similar environments. The writer does not agree that this illustrates "human choice," *i.e.*, that 50 folk choose to live in Darfur for one who chooses to live in Western Queensland. It is merely another example of the stages of development in man's occupation of a specific environment. In a pioneer country, with no population pressure and with high standards of living, we find an early stage with a density of only one-eighth.

Under the competitive conditions obtaining in the Sudan, six folk per square mile can be supported at a very low standard of living. Though it is highly unlikely that Urandanji will ever reach this high density; its population may advance considerably as pressure increases in the rest of Australia. However, a local resident (Mr. V. Bye) writes me in 1941 that only two more houses have been built in Urandanji in the last twenty years, while one original house has been burnt down and one store closed. Hence man has not exercised his powers of choice very noticeably as regards *this* possible site.

7. *Santa Marta—a tropical monsoon town in South America*

For my last example I have chosen a sea-level town only 11 degrees from the Equator. Here with an average monthly temperature of 81.5° F. we find a fairly typical tropical settlement, even though the rainfall of 43 inches is rather small for such a low latitude. Santa Marta in Colombia is the most northern large town in South America. Moreover it lies southwest of the first settlement made in 1493 by Columbus in Santo Domingo. Since the constant trade-winds would drive the early Spanish ships southward to Santa Marta, it is not surprising that Ojeda built a fortress here in 1502, possibly before the foundation of Nombre de Dios in Panamá. Thus our seventh example is in a sense the oldest settlement in North or South America. The town however was not properly established until 1525. My survey was made in December 1930, when I made several short journeys into the Andes, which here reach their most northern position.[8]

A rocky cape projects like a hook to the southwest, and so affords ample

[8] "Settlement Zones in the Sierra Nevada de Santa Marta, Colombia," Griffith Taylor, *Geog. Rev.* 21 (Oct., 1931).

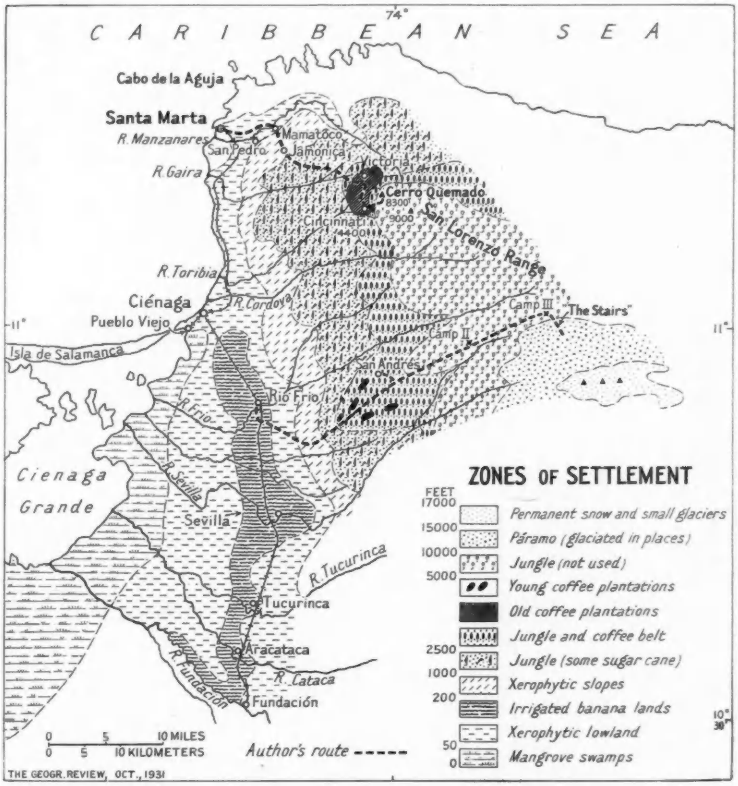


FIG. 8.—Sketch map of Zones of Settlement on the northwestern slopes of the Sierra Nevada de Santa Marta, Colombia. (*Geog. Rev.*, Oct., 1931; republished by courtesy of the Am. Geog. Soc.)

protection from the northeast trade winds. Sixty feet of water is to be found in this bay (Fig. 8), and it is now one of the largest banana ports in the world. The coast is rocky and rises fairly rapidly to 9000 feet in the San Lorenzo Range. Within 40 miles are the ice-clad peaks of the Sierra Nevada, which rise to 18,000 feet or more. My chief aim in visiting Santa Marta was to find how the environment varied with elevation in a region so near the Equator. The zones are summarised in the tabular legend of Figure 8. This table gives a good idea of the hinterland of the town and of its resources.

Thus the settlement originated near the fine natural harbour as a

Spanish outpost to control the Spanish Main. According to E. R. Tirado, towards the end of the 16th century the town already contained six of the present rectangular streets and a church in what is now the southeast of the town. It was however almost moribund by 1882, when the railway to the interior was begun. Today its prosperity depends almost wholly on the banana trade, which is most efficiently directed by the American colony connected with the United Fruit Company of Boston.

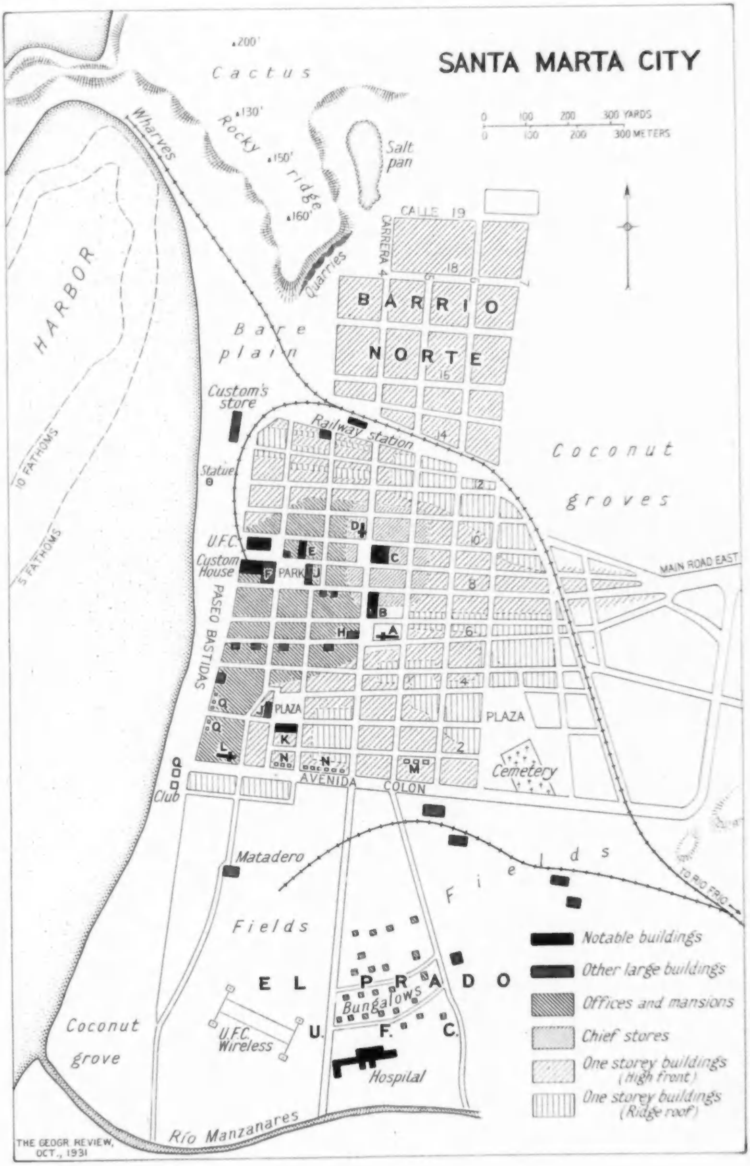
As regards the town itself it is built on the flat plain north of the little Manzanares River. The town, sheltered from the trade winds, is muggy and hot. The natural vegetation on the coastal plain is largely xerophytic (Photo 11). It is very dusty in the frequent dry spells, yet no roads have

PHOTO 11.—The town of Santa Marta, perhaps the earliest settlement on the mainland of America (1502). Notice the arid vegetation (cactus) in the foreground. View looking to the south, with the Caribbean Sea to the right.

been built into the surrounding hills, not even to the coffee haciendas some 18 miles to the east, which are still reached only by mule tracks.

It is not difficult to distinguish that part of the town which is purely Latin-American from that which has developed mainly as the result of the

FIG. 9.—Map of the city of Santa Marta in Colombia, based on the city plan 1929. Reference: A Cathedral; B Municipal Palace; C Market; D Church of San Francisco; E Governor's Palace; F Cuartel; H Bishop's Palace; J Schools; K Law Courts; L Hospital; M, N, Q, Quintas. El Prado is the suburb of the United Fruit Co. (*Geog. Rev.*, Oct., 1931; republished by courtesy of the Am. Geog. Soc.)


SANTA MARTA CITY
0 100 200 300 YARDS
0 100 200 300 METERS
Cactus
Rocky ridge
Wharves
Salt pan
Quarries
HARBOR
CALLE 19
CARRERA 4
BARRIO NORTE
Bare plain
Custom's store
Railway station
Coconut groves
Statue
10 FATHOMS
5 FATHOMS
U.F.C.
Custom House
PARK
PASEO BASTIDAS
MAIN ROAD EAST
PLAZA
Cemetery
Club
AVENIDA COLON
Matadero
Fields
TO RIO FRIO
EL PRADO
Bungalows
U.F.C.
U.F.C. Wireless
Hospital
Coconut grove
Río Manzanares
Notable buildings
Other large buildings
Offices and mansions
Chief stores
One storey buildings (High front)
One storey buildings (Ridge roof)
THE GEOGR. REVIEW, OCT., 1931

recent commercial growth of Santa Marta. There are four types of buildings, which together constitute practically the whole of the town. These are arranged in definite zones, and are plotted in Figure 9. The foreign business is chiefly in the west, and the local business in the centre. The poorer people live chiefly in the east.

One-storey buildings prevail save in the west of the town, and only a few of the larger public or private buildings have three storeys. Santa Marta is the capital of the large Department of Magdalena, and some of its official buildings are quite pleasing in appearance. In the southwest of the town are a number of villas in gardens, and they more closely resemble the houses of northern peoples.

North of the town has arisen a barrack-like suburb largely inhabited by laborers on the wharves. Very different is the suburb south of the city where under beautiful poinciana and acacia trees are the bungalows of the United Fruit Company.

How does Santa Marta illustrate our discussion on Possibilism? The fine harbour was no doubt a major factor determining the original site, while the lack of any easily exploited resources led to the long stagnation of the town. It will no doubt be stated that its present prosperity is largely due to the initiative of certain Bostonians. This is no doubt true; but the Bostonians were led to Santa Marta by the unique environment; in which numerous ice-fed streams flow down to the Caribbean plains. Irrigation is the key to the expansion of the town in the last 40 years, and this is surely a gift from nature; developed of course by human initiative. The United Fruit Company could build a railway anywhere along the Spanish Main. They wisely "chose" the one district where large-scale irrigation was possible. The present writer credits the expansion of a town based on a "Hobson's choice" of this kind to the account of the determinists.

Section B

CANBERRA—THE CITY BUILT TO A PLAN

One of the most interesting human clusters is that of Canberra, the capital of the Commonwealth of Australia. Most of the world's chief capitals have been fairly large towns before they became of great political importance. For instance, there was a considerable population at Ottawa before it was chosen in 1858. Washington on the other hand seems to have been of little or no importance before 1790, when Hamilton, it is said in return for political favours by Jefferson, agreed to the latter's desire to place the capital on the Potomac. However Canberra belongs to this century's history, and every detail of its development is ascertainable. Moreover the writer had a fairly close personal association with the capital in its earliest years, which may add to the interest of this brief record.

In 1900 it was decreed that the capital should be built in the state of New South Wales. But partly due to the jealousy of the other states it was ruled that the city should not be less than 100 miles from Sydney (the state capital). Since the western part of New South Wales is so hot and dry that it is not suited for agriculture, it is clear that the new city would develop in the rather elevated and wetter areas in the east of the state. Various commissions visited suggested sites, and the first inspection placed Bombala ahead, with Yass and Orange second (Fig. 10). In 1903 another

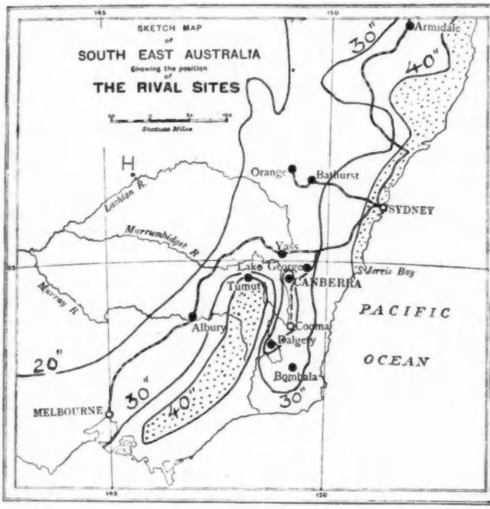


FIG. 10.—Map of eastern New South Wales to show the rival sites for the Capital, 1902–1908. The main isohyets are shown, and the regions with over 40 inches are dotted. Note the dry area between Dalgety and Canberra. H is Hillston. (Base-map published by the author in *Geog. Jnl.*, April, 1914.)

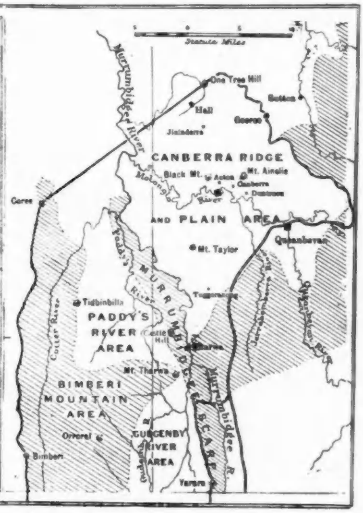


FIG. 11.—Map of most of the Federal Capital Territory in the southeast of New South Wales. The ruled areas are rather high and rugged. The small black square near Acton shows the centre of the new city. (First published in the *Geog. Jnl.*, April, 1914.)

commission favoured Albury, with Tumut, Orange, and Armidale following. Then Parliament voted, and chose Tumut in 1903, and Dalgety in 1904. In 1908 at the final discussion, Yass-Canberra was elected, through the union of the parties supporting Yass, Lake George, and Canberra, which are all in the same region. The territory around Canberra, comprising 900 square miles, was vested in the Commonwealth on 1st January 1911.

Probably any of the ten places shown on the map would have been fairly suitable. Canberra has however some advantages. It lies close to the route linking the two chief cities of Sydney and Melbourne. It is 1900 feet above the sea, which gives a cooler climate than that of most of the sites. It is close to a long plateau (Bimberi) which rises over 6000 feet, and here the Cotter river acts as a valuable collecting ground for the water supply of the city.

Canberra is on the line joining the centre of population of Australia (at Hillston, **H** on Fig. 10) to the east coast. It is not too far from the Federal

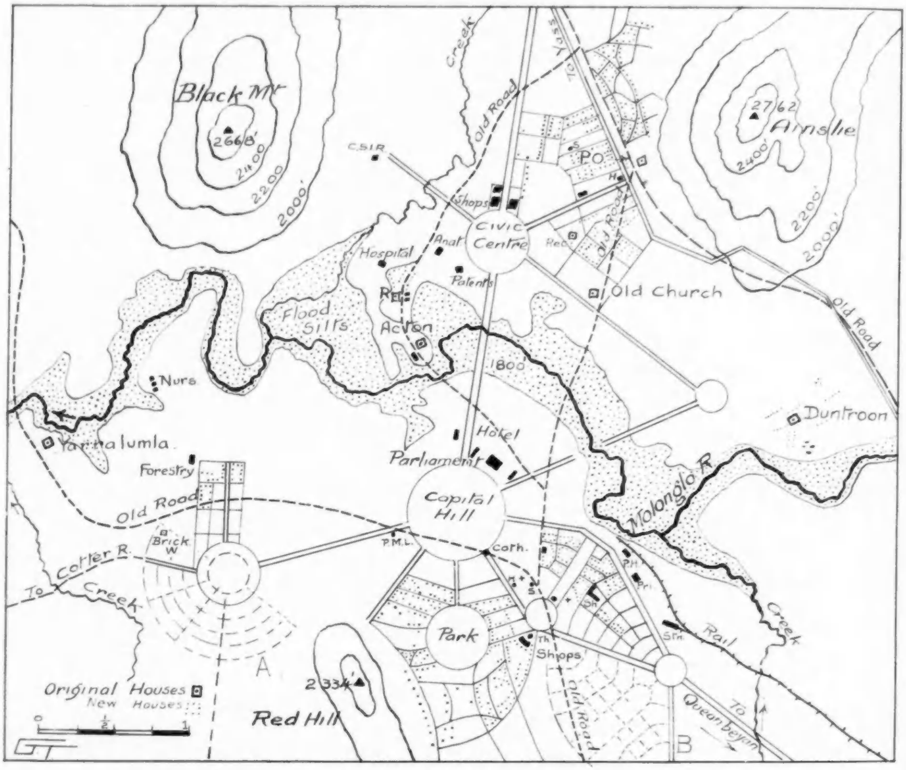


FIG. 12.—Map of the new city of Canberra, the capital of the Australian Commonwealth. Note the Molonglo River running west to the Murrumbidgee River. The half dozen original houses, and the early roads (broken lines) are indicated. The "cobwebs" in broken lines are part of the design, but have not yet been built. (From the Official Map, 1933.)

port at Jervis Bay, and yet it cannot be shelled from the sea. On the other hand the rainfall is low (23 inches), since the site is at the north end of the Cooma rain-shadow strip (Fig. 10). This however meant that the land was used primarily for grazing, and was not in private hands. It is in the faulted area of southeast Australia; but earth-tremors, though not uncommon in the district, have never been alarming.

The two first pastoralists settled in the district about 1823; and one of these used the name Canberry for the district which surrounded his ranch, which he called Acton. The other built the house named Duntroon on the adjacent ranch to the east. The same squatter also erected the church at Canberra in 1826. For a time Acton was in the hands of the Brasseys—a well known naval family in England. Further west was Yarralumla, now used by the Governor General. The whole Federal Territory was occupied by a score of stations (ranches) mostly raising sheep, but in the very rugged southwest section beyond Tharwa cattle are grazed.

By 1909 there were a few tiny settlements serving these stations, such as Canberra, Tharwa, Hall, and Uriarra, some of which are shown on the map (Fig. 12). The total population was about 1500. The writer had described the topography of the upper Molonglo River as early as 1907 (in his paper on Lake George), but did not visit the actual site until July 1910. At this time the Federal Survey was housed in tents and in two fabric huts just north of the Red Hill. Today the Prime Minister's Lodge occupies almost the same spot. (P.M.L. in Fig. 12.) A preliminary paper on the topography of the Territory appeared in December 1910 (*Meteorol. Bulletin 6*); and I gave a full discussion of the topography and history in the *Geographical Journal* (London) of 1914.

There were only two large houses on the city site in those early days. One was Acton used by the Surveyor General, and the other was the Rectory about a mile to the northeast. A little house near Ainslie was the official post office (Photo 12). Duntroon to the east soon became the nucleus of the Military College; but it is still well outside the city, though a flourishing suburb of the latter. The main road led from Queanbeyan to Yass and ran just to the east of Ainslie. Here another road came up from Tharwa in the south, while less important roads led to Acton and Yarralmula. All these are shown by broken lines on Figure 12.

After my return from Antarctica I was engaged on the geological survey of the Territory. Our chief object was to find brick-clays and building stones, which unfortunately are not altogether satisfactory in the Territory itself. By 1912 there were several wooden cottages near Acton for the surveyors and clerks. A post office, drawing office, and bank had also been erected in the vicinity, and a large house (R. in Fig. 12) was built for the Adminis-

PHOTO 12.—Canberra in 1928, a view looking across the Molonglo Plain towards Mount Ainslee, *i.e.*, to the northeast. The Parliamentary centre is in the foreground, while the municipal centre is two miles away in the left background.

trator. Soon a short railway was run in from Queanbeyan eight miles to the east; while the Power House (P.H.) was perhaps the most ambitious building in those early days.

Meanwhile plans were invited for the future capital, and those of a Chicago architect (W. B. Griffin) were chosen. The actual street-plan follows his design, which gave much prominence to the local environment. The city has developed in a broad flat plain between three conical hills, which rise respectively 400, 700, and 800 feet above the Molonglo plain (at about 1900 feet). The Molonglo river winds in its flood-silts across this plain, running westward to join the Murrumbidgee River (Fig. 12). The main vista is the view northwards between Black Mountain and Mount Ainslie. Here Commonwealth Avenue was made the axis of the chief corridor; and it leads northwards from a low hillock, called Capital Hill, to the Civic Centre across the Molonglo River.

The cobweb pattern was adopted, with two main cobwebs at Capital Hill and the Civic Centre. But other cobwebs were also laid out, most of which are still only in the embryo stage. However in my sketch map I indicate a number of these lesser cobwebs; *i.e.*, one northwest of Red Hill and three between the latter and the railway station. Another lies near Duntroon, while the largest cobweb of all is quite outside the sketch map to the north. This last is not yet bordered by any houses. It will be noticed

that there is not much similarity between the simple early road-pattern (shown by heavy broken lines) and the rather complicated cobwebs of today.

The actual arrangement of modern houses is indicated in Figure 12, though every small street is not included. It will be seen that there are three or four scattered quarters separated by wide spaces where the streets have not been developed yet. South of Capital Hill are the largest houses, with the Prime Minister's Lodge (P.M.L.) in the north. Another quarter served by a cluster of shops and a theatre is to the east. Still further to the east are the Railway Station, Power House and Printing Office with adjacent houses. Parliment House and the chief Government buildings, are about a mile north of these residential quarters (Photo 13).

PHOTO 13.—Looking southwest over Canberra. The view shows the Parliament Buildings in the right foreground. The long flat ridge of Mount Bimberi (6264 feet) appears in the background. (Courtesy, Government Printer, Sydney, N.S.W.)

The Civic Centre is three miles to the north across the river, and the other main sections of the town lie between it and Mount Ainslie. The latter sections occupy the once empty plain between the old Rectory and the

post office, where the writer investigated the claims of certain water-diviners way back in 1920.[9]

In the sketch map (Fig. 12) the streets in use are indicated, while some of them not yet laid out (near Red Hill and railway station) are suggested by broken lines. Presumably similar streets will in the future fill all the empty portions of the map, as well as the flat plain north of the Civic Centre. A dozen small parks are scattered among the street blocks, but they are omitted in my sketch plan. The splendid plantations in the west of the city are an attractive feature, and a small hamlet has developed near the Forestry Building to care for them.

Clearly we have here a departure from the plans of most cities of today. The experiment of splitting up a small town of some 7000 people into civic and political units is very interesting. The rather wide distance between the southern and northern clusters seems at present to waste a good deal of citizens' time. But in Canberra the designer is commendably looking forward to a city of three or four times the present size. It must be confessed that the choice of a cobweb plan supports the possibilist's thesis.

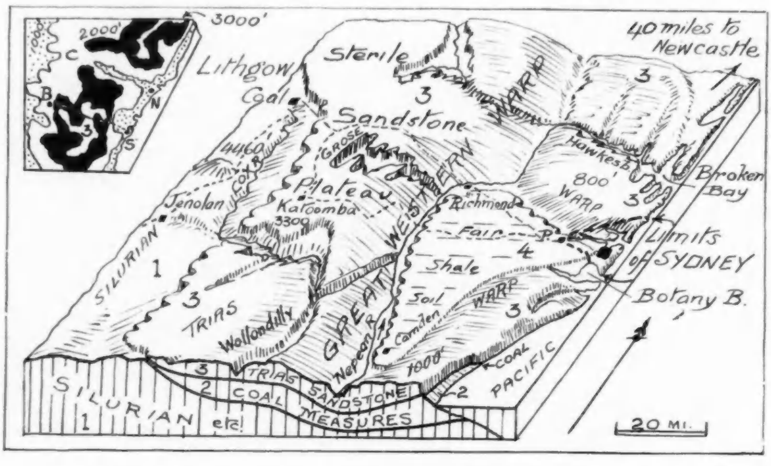


FIG. 13.—Block diagram of the region around Sydney, Australia, showing the chief geological strata (1–4), and the three monoclinal warps. The sterile sandstone is labelled 3. The area of shale soil (4) accounts for the closely-settled area in Figure 14. Note that practically all the road and rail traffic to the west passes through Lithgow. Inset is a sketch map to compare elevations between Sydney and Bathurst with those between Newcastle and Cassilis.

[9] "Water Divining" Griffith Taylor, *Royal Soc. Victoria*, (May, 1921). A map of the empty site may be found of interest.

The siting of the individual cobwebs has however been wisely influenced by the relation of the river to the striking conical hills. Hence, as usual, in city evolution, we must agree that nature and man both play important parts.

Section C

SYDNEY—A METROPOLIS STRONGLY AFFECTED BY GEOLOGICAL CONTROLS

Having granted that the details of a city are man-made and lend small support to the determinist, let us devote a little time to the *broader* aspects of a city's evolution. We shall find that here the possibilist thesis meets with much less encouragement. Sydney—the largest city in Australia, and the second in the British Empire—has perhaps the most unusual umland that the writer has investigated. Its population is 1.3 millions, and in U.S.A. is only exceeded by New York, Chicago, Philadelphia, and Detroit. It offers us an interesting study, in part because the first settlement was so recent as 1788. The writer lived in Sydney for over 20 years, during most of which he was connected with the University there.

In 1770 Captain Cook discovered the east coast of Australia, and he spent some days at Botany Bay (Fig. 13). Sir Joseph Banks was greatly impressed by the new flora which he observed here; and later he advised the British authorities to make the first settlement at Botany Bay. When the First Fleet arrived in 1788, Captain Phillip was not much taken with the wide shallow bay or its sandy shores, and he preferred Port Jackson about 12 miles to the north (Photo 14). This magnificent harbour had not been visited by Cook. We may well consider for a few minutes the interaction between man and environment in this locality.

The build of the Sydney district is relatively simple. A somewhat elongated geological "basin," with its centre just west of Sydney, is built up of three main formations. The foundation rocks are Silurian slates and limestones (1 in Fig. 13). Above these comes a thick series of Coal Measures of Permo-Carboniferous age (2). Two very valuable series of coal seams are found in these beds, of which the upper series lies about 3000 feet below the city of Sydney. This coal outcrops on the coast at Newcastle to the north, at Coalcliff to the south, and also at Lithgow, some 70 miles to the west of Sydney. Above the Coal Measures is the determining factor in human settlement around Sydney. It is a widespread layer of rather *coarse sandstone* about 1000 feet thick, which covers an area of about 1200 square miles. This layer of Trias sandstone (3 in Fig. 13) is usually bounded by vertical cliffs, and these are suggested on its western edge in Fig. 13. Along the coast both at Sydney Harbour and at the mouth of the Hawkesbury River, the coast consists of similar high sandstone cliffs. (Only the southern third of this sandstone area is shown in Figure 13.) It weathers to a sterile

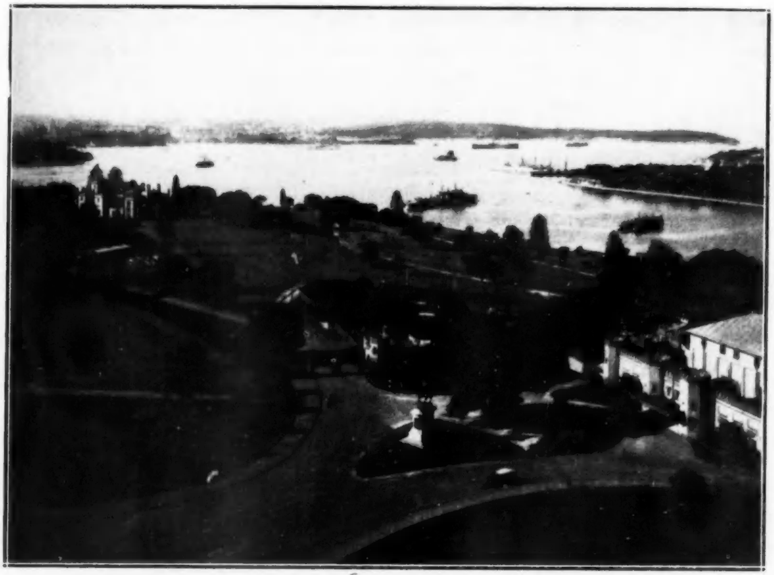


PHOTO 14.—Sydney Harbour, looking to the northeast, from the park around Government House, which appears in the left foreground. The narrow outlet of the Harbour to the Pacific is four miles away in the right background. (Courtesy, Government Printer, Sydney, N.S.W.)

sandy soil, which is covered with heathy plants or scrubby trees, and supports no crops of importance. Above this Hawkesbury Sandstone is a layer of Trias shale (4), which gives rise to clay soils of much greater agricultural value.

Probably if these surface strata were relatively level and undisturbed, far better conditions for close settlement would have arisen, through the deposition of silts, humus, etc. But quite lately in geological time the margins of this irregular basin were warped upward. To the *north* of Sydney is a fairly steep warp amounting to 800 feet, to the *south* the land was raised by a gentle incline to a height of 1000 feet, while to the *west*—at a distance of 35 miles—a very marked hinge-line developed. To the west of this line the surface was elevated to a height of 3000 or 4000 feet in a remarkable "monocline." As the land rose, the Nepean River was forced to flow along the remarkable series of short gorges and alternating flats which I have described elsewhere. (These latter are omitted in the sketch Fig. 13.)

As a result of these uplifts, especially in the west, the topography around Sydney is much dissected. Indeed near Katoomba are canyons 2000 feet

deep, of which some (like the Grose Valley, Fig. 13) end to the west in giant cliffs (Photo 15). This dissected topography has always blocked communi-

PHOTO 15.—This wide canyon near Katoomba is about 8 miles across and 2000 feet deep. It is eroded in the Triassic sandstones of the Blue Plateau. This canyon has a bottle-neck outlet-gorge only a few hundred feet wide, where it enters the Nepean River in the plains. (Courtesy, Government Printer, Sydney, N.S.W.)

cations, and indeed not for a quarter of a century could the settlers find a way across the sandstone plateau. However the centre of the original basin was not elevated; so that here the upper layer of shales was preserved, while the soft shales were soon removed from the up-warped marginal surfaces.

We now have the key to the remarkable umland of the city of Sydney. The distribution of population is given in Fig. 14. If we draw a circle of 50-mile radius about Sydney (with its 1.3 million inhabitants) we find one of the most singular dispositions of circum-metropolitan population in the world. Let us suppose that we survey this belt from an aeroplane. On the north our flight leaves the narrow coastal plain at Wyee. Thereafter for 80 miles we cross only one good road. The next 20 miles crosses Bell's Road and the tourist centre of Katoomba. Proceeding south for 40 miles we notice the single settlement of the Yeranderie mines, before we reach the

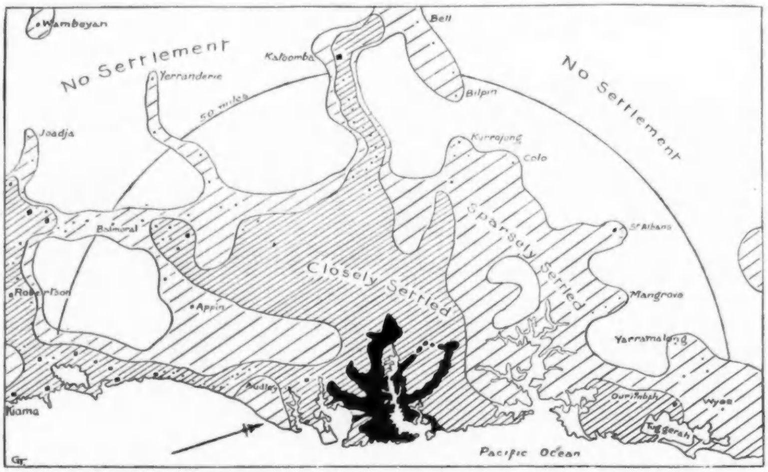


FIG. 14.—The distribution of settlement around Sydney. The region of city streets is shown *black*. The region where centres are less than about four miles apart by *close ruling*. (N. B. Closely settled areas begin again somewhat to the west and north of this map.) (From *Royal Soc., New South Wales*, 1923.)

railway line at Balmoral. Another 20 miles of uninhabited water-reserves brings us to the narrow coastal plain near Kiama, and here again a closely settled region is observed. Thus, excluding the shore, during a flight of over 150 miles we have only crossed two narrow belts of settlement (at Katoomba and Balmoral) while circumnavigating the largest city in Australia.

It must of course be realised that, after we have passed to the *west* of the sterile Hawkesbury Sandstone, the normal density of a farming population is soon reached again. For the most part this better country lies outside the area of Figure 13, but a little of it shows near Lithgow.

It may be noted that though Sydney is by far the largest town with probably the best harbour in Australia, yet it has these grave disadvantages of restricted farmlands and difficult approaches to the hinterland. At Newcastle 70 miles to the north, a large river, the Hunter, enters the sea after flowing through much better agricultural land. A quite adequate harbour, in part artificial, is to be found at Newcastle. Here also outcrop the best coal seams in the southern hemisphere. Behind Newcastle is the Cassilis Gate; a broad low corridor of access to the interior, and far superior to the Lithgow-Bathurst route, as is obvious from the inset map in Figure 13. In the latter case the main Western Railway has to climb up to 3300 feet or more on its way to the west, while the Cassilis Gate is little more than 1000 feet above sea level. Yet there is still no railway through Cassilis; and

Newcastle with all its advantages has only a population of 105,000. If Phillip had decided to found his first settlement at Newcastle, one wonders if Sydney might not have been nearly as empty today as the similar harbour of Broken Bay (Fig. 13). Here then is an example of man's choice of a city site with some notable disadvantages, which in part offset the splendid harbour. The writer will not attempt to compare the respective total attractions of the two sites of Sydney and Newcastle, but the topic is of more than local interest. The answer may be clearer in a hundred years' time.

Section D

TORONTO—STAGES IN THE DEVELOPMENT OF A LARGE CITY

Let us study the way in which a large city, such as Toronto, has evolved in about 150 years. Its topography is shown in Figure 15; while the main

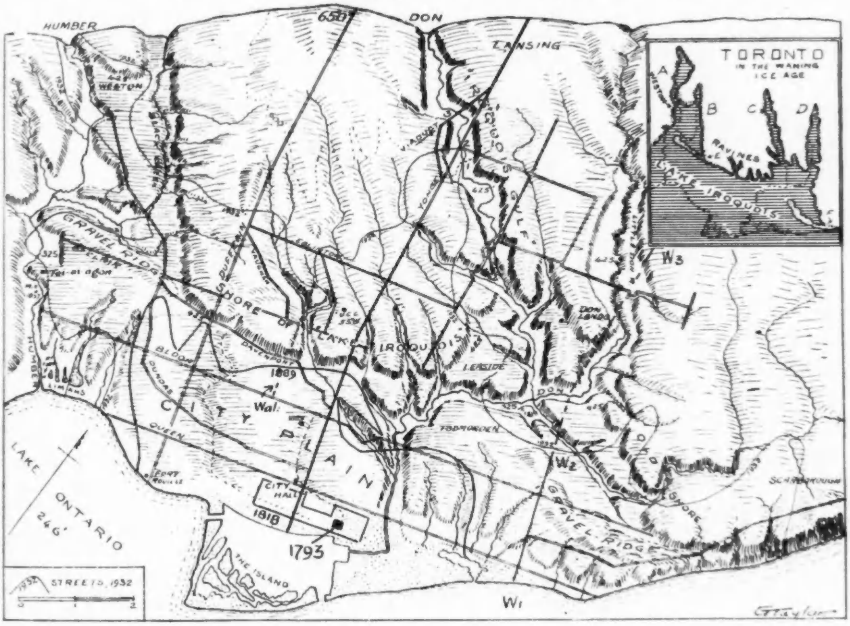


Fig. 15.—Block diagram of the City of Toronto, showing the topographic features which have affected the evolution of the city. Inset is a diagram showing the locality at the Lake Iroquois period. The fine lines labelled 1889 and 1932 show the edges of the streets with close-set houses at those dates. w1–w3 is proposed Woodbine Avenue; "Wal." is Walmer Road. (From *Can. Jnl. Econ.*, 1936; with additions.)

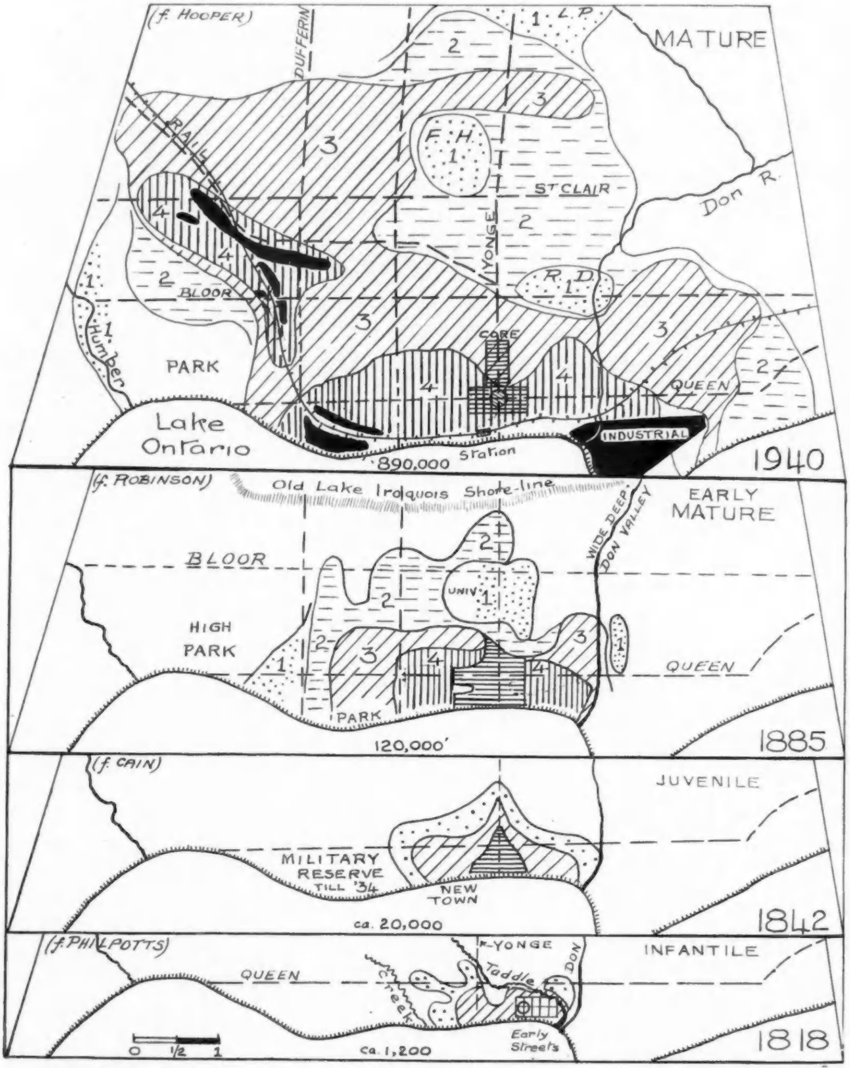


FIG. 16.—Stage-diagram to show the evolution of the city of Toronto. The four maps are to the same scale, the earliest at the bottom. The various rulings indicate the various elements of the city pattern. 1, 2, 3, 4, are the four types of city residences, varying from mansions (1) to the poorest types (4). The zones are, of course, somewhat generalised. The "commercial core" includes the large Department Stores.

stages of development are shown in Figure 16, where only the salient characteristics are charted. In a large city we need to know the position of the commercial core, the industrial areas, and the general characters of the residential quarters. The latter may be *fourth* class (Hd), small inconvenient (or decayed) houses without gardens; *third* class (Hc), better houses but still without much space or convenience; *second* class (Hb), modern two- or three-storey brick houses with fair gardens; or lastly *first* class (Ha) with rather large gardens for a town, and of the type that at times might be called mansions. These types of residences are numbered 1, 2, 3, and 4 in the maps for 1885 and 1940 in Figure 16.

If we ignore the other details we see that there is a constant change in the position of these zones. This change takes place in two ways. The best class houses of one decade become the second class houses of a later decade. But this change in zonal distribution is complicated by the building of new suburbs of various classes in the marginal hitherto empty regions. There is therefore no very close resemblance between the development of a city and that of an animal. But it is something like the way a young tree grows. Its trunk and branches increase by a sort of expansion, while quite new characters such as flowers and fruit appear as it reaches maturity.

The lower diagram in Figure 16 shows Toronto in 1818. The original grid of nine streets was laid out about 1790, on well-drained ground at the head of the enclosed bay, near the Don outlet; where also the best protection from naval attack was presumably to be gained. The junction of King and George streets was the early centre of the city. By 1818 small industries such as tanning and brewing were scattered near the original settlement. A few larger houses were built on the margins of the town, but all but a few of the dwellings were still built of wood. The population was about 1200 at this time, and the built-in area covered about half a square mile. As usual in such a young organism it is not possible to distinguish the zones, which will only differentiate at a later date.

By 1842 the town had about 20,000 inhabitants. The centre had shifted to the lower end of Yonge Street, the main corridor to the interior. Swamps near the foot of Yonge Street tended at first to isolate the old from the new portion of the town, but these were filled in by degrees; so that by 1842 this swampland was becoming the commercial core of the city. The houses were still small for the most part, but finer residences were being built on the northern margins. One of these was the Grange, which is now part of the City Art Gallery. The built-in area (diagonal ruling) now covered about two square miles.

In 1885 the town contained about 120,000 citizens, and extended over most of the City Plain, between the lake and the 40-foot cliff of the old Lake Iroquois Shore-line. The commercial core has moved a trifle north, but

still keeps to the Yonge Street axis. The houses are now numerous enough to show a fairly clear *zoning*, ranging from the poorest houses (4 or Hd) up to near-mansions (1 or Ha). The underprivileged live near the heart of the city, in old houses for the most part. The wealthy are building large residences on the margins, where parks (as in the west) or deep ravines (as in the east) promise security from further encroachment. The built-in area covers approximately eight square miles. The city is definitely growing to the northwest, mainly because the deep wide valley of the Don bars ready access to the east. The little stream-valleys also guide the expansion in the same direction. It is still not easy to differentiate between the commercial and industrial areas of the city. In a later section (p. 59) we shall label such a stage of development as Early Mature.

In the modern city of 1940—which contains nearly 900,000 inhabitants, if adjacent satellites are included—there has been an enormous expansion of houses in every direction, but especially to the north and northwest. The old shore-line ceased to be the northern boundary about 1890. A great development of industrial plants has taken place, especially along the main railways west of the city, and on the filled-in lake areas to the southeast of the city. The commercial core has broadened somewhat, but is still clustered about Yonge, Queen, King and Bay streets. Here also are the large department stores, which have not been differentiated in my discussion.

In the last half century the third-class houses have become the poor-class houses of 1940. The earlier first and second-class houses have been hemmed in by the growing city, riddled with small shops and with small industrial establishments. They have become the third-class houses (3) of today. To keep pace with the immense growth of the city, now seven times as populous as in 1885, vast areas of third-class houses cover most of the City Plain; but naturally many of the better houses (2) hold their own in the marginal portions of zone 3. The modern zone 2 has developed mainly along Yonge Street, the main corridor to the north, especially near the fine west-east avenue called St. Clair. In the extreme west near the Humber, and the extreme east towards Scarborough Cliffs, there are other clusters of second-class houses.

The positions of the four first-class suburbs (1, or Ha) are interesting. Partly they occupy the margins of ravines, as near Lawrence Park (L.P.) in the north, Rosedale (R.D.) in the east, and Humberside in the west. But the development of Forest Hill is perhaps due to the times of prosperity about twenty years ago. The high rolling hills of till, here about 300 feet above the lake, were beyond the city at that date, and were rapidly covered by large and expensive mansions. Possibly no similar development will

occur again, since both the children in families and domestic servants are now rather rapidly declining in numbers.

Tentative "ages" of a city

I have labelled the four stages shown in Figure 16 with the names so familiar to us in regard to an evolving landscape. Most progressive cities of the occidental type go through similar stages. In the earliest stage there is no clear differentiation between industrial, commercial, or residential areas. The first tendency is for the bigger houses to develop near the margins, where gardens and privacy are available. We see Toronto in this infantile stage up to 1818.

In the next stage there is a fairly clear segregation of an extensive commercial quarter towards the centre of the town, including a number of streets without residences. But shops, offices and small industries are still rather mixed. A definite zone of better-class houses fringes the town. The poorer folk live near the centre; in many cases taking over the better houses of the former stage, but also building new small houses in any empty spaces. This may be called the *juvenile* stage, and is illustrated around 1842 in Toronto.

The beginning of maturity is shown by a definite differentiation of the residences. The various types are displaced outward as the years move on, though naturally examples of the early houses survive in the expanding zones. In 1885 the four classes of residences mentioned earlier were beginning to become evident. Poor quarters (4) clustered around the centre of the town. The best residences were on the margins, but were not numerous enough to form a connected zone. High Park in the west helped to determine the zone. The ravines at Rosedale attracted another area of good houses. This stage is *adolescent* or *early mature*.

In the mature stage of Toronto we see that the concentration of industrial areas along the railways and on the made ground is the chief change in the conditions. Toronto is still growing, but the main axis of growth (*i.e.*, the central line of the new industrial zone) is now along the railway to the northwest. There is a separation of the industrial city from the residential city, and the city is *mature*.

Perhaps when a definite zoning is carried out according to a laid-down plan (such as is indicated in Canberra) a city may be said to reach its zenith or climax; in geographical language it is *late mature*. The *senile* condition of a city is not indicated in Toronto. Such towns as Pekin (Fig. 5) or Nanking, with vast areas originally covered with houses but now heaps of ruins, may perhaps be described as partly senile. But the complexity of a large and ancient city is like the complexity of a long river like the Nile. Parts of the Nile are juvenile, others mature, others senile, depending on external factors developing during the life of the river.

Environment and the city's growth

A city is obviously an artificial growth. Nature produces nothing resembling a city, and so at first glance would seem to have no say in the development of a city. I have discussed this aspect of the problem as regards Toronto in several publications.[10] Here therefore I will only introduce one diagram (Fig. 15), and point out a few examples where nature's lay-out might well have been considered in deciding man's design.

The Toronto environment consists of a topography built up wholly of glacial debris, either till or sands. These are 300 feet thick in the upper part of the town, and about 60 feet thick in the lower part. Rock outcrops are absent everywhere, except in the bed of the Humber. The City Plain extends from Lake Ontario (246 feet) up to the Iroquois shoreline (425 feet). Here a sharp slope, almost a cliff 40 feet or more in height, (which was cut out by the waves of former Lake Iroquois), separates the lower from the upper town. The Canadian Pacific Railway runs along the foot of the Iroquois shoreline and definitely blocks road communication with the upper suburbs.

The chief natural features of the town, however, are the ravines, which have been eroded in the till by the drainage from the former ice-sheet. These are 50 to 100 feet deep, and in general run from northwest to southeast (Fig. 15). The civic fathers followed the usual chessboard lay-out of the streets, with their axes near the cardinal directions. Hence the roads have been made without the slightest reference to the ravines, and without much regard for the main objective of the citizens' journeys (which was to reach the centre of the city). Some of the most expensive city-viaducts in the world have been built to cross the Don and Humber valleys. These were inevitable, but others over the smaller ravines need not have been built if the roads had been built *along the divides* between the ravines. In the west part of the town such roads would have the added advantage that they led directly to the centre of the city. For instance, Vaughan Road running diagonally *between* ravines is a much more sensibly designed road than Spadina Road with its huge viaduct.

In Toronto, as in many other fairly modern cities, the chessboard was laid out on the surveyor's chart, and often the roads were named before construction. Thus we find a continuous Walmer Road in the middle of the city map (see Wal. on Fig. 15), but actually it is still in three isolated pieces. These sections are separated from each other by the Iroquois cliff, or by deep ravines, or by the railway.

The most amusing example is Woodbine Avenue (W1, W2, W3 on

[10] "Topographic Control in the Toronto Regon," Griffith Taylor. *Can. Jnl. Econ.*, (Nov., 1936).

Fig. 15) which has a gap three miles long in its continuity from W2 to W3. It seems hardly likely that the whole of the Little Don valley will be filled up to enable the surveyor's design to be maintained! Yet this is merely a large-scale example (of which we see many smaller illustrations) of the absurdity of ignoring the environment in planning the development of a large city. Lack of space forbids my enumerating many other examples of man's unsatisfactory choice of plan in this connection.

The writer would like to enter a plea for the use of the block diagram (as in Fig. 15) to illustrate the setting of a city. Its history may be so easily summarized therefrom, as follows:

The first houses in 1793 were built near the black square in the southeast. This is the "nucleus" of the city. By 1818 the little town had spread along the shoreline. Two isopleths, indicating the outer limits of built-in streets in 1889 and 1932, show the expansion of the city at two later periods. The large valleys of the Humber and the Don, the small glacial-water ravines and the Iroquois shoreline are clearly represented. This illustration should be used in conjunction with the stage-diagram (Fig. 16).

Section E

THE "ZONES AND STRATA" CONCEPT APPLIED TO CITIES; TORONTO, PORT CREDIT AND WHITBY

In the case of large human movements—such as racial migrations—the use of the zones and strata technique enables us to deduce the cradle of human evolution and the order of development of the races.[11] But it is also of considerable value in connection with the much smaller agglomerations of man which we call villages and cities. Here also we are concerned with clusters of folk about the original nucleus, about which the town gradually expands.

What value has this technique in city evolution? Perhaps in connection with house-types we see the process most clearly. The first houses at Toronto were *log huts,* of which one is actually still preserved in the Exhibition Grounds. This was originally erected where Queen Street crosses the Don River (Photo 16). The nearest log hut, in use today much as it was originally, is (as far as I know) in Queensville, 35 miles north of Toronto. Thus the first stage of house has now been pushed out for 30 miles or so from its original position. The second type was the small *frame house* built of horizontal planks. I recently photographed one of these houses in the heart of the city in Queen Street opposite Osgoode Hall (Photo 17). It has now been pulled down, but plenty of specimens still remain in corners of the city. They are now found fairly numerously in the little towns near Toronto;

[11] See the writer's *Environment, Race and Migration* (Chap. 21).

PHOTO 16.—Two log-cabins which illustrate the application of the "Zones and Strata" technique to the evolution of Toronto. The cabin on the left was built about 1800 right in the early village of Toronto. Today, the occupied cabin on the right (at Queensville, 35 miles from Toronto) shows how far this type of building has been displaced from the centre of the city.

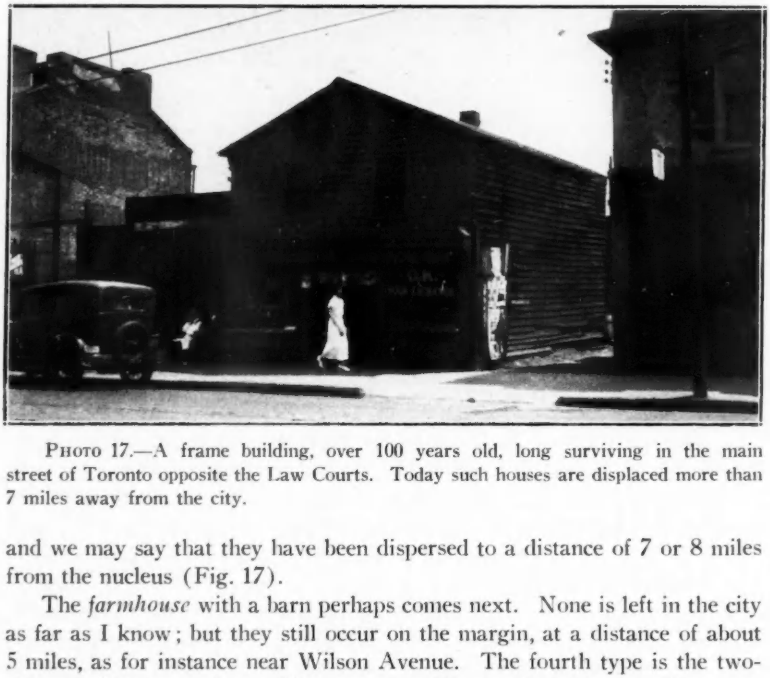


PHOTO 17.—A frame building, over 100 years old, long surviving in the main street of Toronto opposite the Law Courts. Today such houses are displaced more than 7 miles away from the city.

and we may say that they have been dispersed to a distance of 7 or 8 miles from the nucleus (Fig. 17).

The *farmhouse* with a barn perhaps comes next. None is left in the city as far as I know; but they still occur on the margin, at a distance of about 5 miles, as for instance near Wilson Avenue. The fourth type is the two-storey *brick* house often with a snow-shedding gable in front. These are still common in the third- and fourth-class houses in the city. They are of

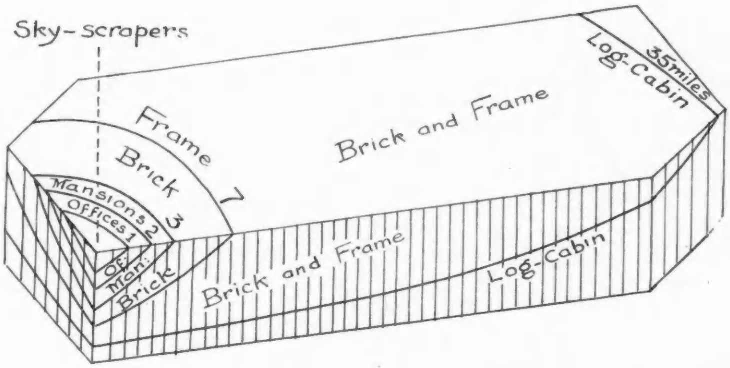


FIG. 17.—A block diagram illustrating the "Zones and Strata" technique applied to the evolution of Toronto. The first houses were log-cabins now displaced 35 miles away from the city; but an early specimen still remains in the city. So also the later types of frame-houses, small brick houses, mansions, etc. have been displaced successively from the nucleus of the city.

course almost universal throughout Lower Ontario, being the usual type of farmhouse built during the last half century.

The remaining types are the mansions and sky-scrapers. The Grange was built in 1817 only a mile from the Lake. It is a large *mansion* still in use as part of the Art Gallery. Today houses of this type and culture are not found nearer than Rosedale or Forest Hill, *i.e.*, about 4 miles north. Finally in the busiest part of the city we find the latest type of building, the *sky-scraper,* which is almost wholly found in the vicinity of Queen, Bay, and Yonge Streets. They of course constitute the most striking buildings in the commercial core.

The zones are therefore fairly definite today. If we assume that the few relics of older types still remaining are fragments of ancient "strata," most of which have been "buried" (*i.e.*, removed), then the evidence given above shows how the technique can be applied to city evolution. In other words all the types originated near the heart of the modern city (near the "nucleus"); but the older the type the further it has been displaced to the margins as the city evolves. Conversely from the distribution of these zones we can deduce the way in which the houses have evolved.[12]

The data can be summarized in a table as follows, with the oldest types of building at the foot of the table.

[12] The writer first used this technique for Chicago; see his paper "Geography, the Correlative Science." *Can. Jnl. Econ.* (1935), p. 542.

ZONES OF HOUSES

Order	Type	First site	Present position	Displacement from centre
6.	Sky-scrapers	Centre of city	Centre of city	(Area 1 mile wide)
5.	Mansions	do.	Margin of city	3 or 4 miles
4.	Early brick houses	do.	Throughout province	?
3.	Farmhouses	do.?	do.	5 miles
2.	Frame houses	do.	Especially in pioneer areas	7 miles
1.	Log cabins	do.	Obsolete	35 miles

The circumspice[13] concept illustrated by Port Credit and Whitby

Darwin, while studying coral reefs, realised that amid the many examples in the Pacific there were likely to be reefs in all stages of evolution. In effect he said "Look around you, and you will be able to reconstruct the evolution of the coral atoll." The epitaph of Wren the architect in Saint Paul's in a sense contains the same idea, *"Si requiris monumentam, circumspice."* We can usefully apply the same concept of "looking around you" to city evolution. The village is father to the city; hence if we study a village in the same environment as the city, we shall learn something as to an early stage in the evolution of the city.

I have made a number of surveys of towns and villages in southern Ontario, and I think it will be of interest to discuss two of these. Port Credit is a little town on the lake 13 miles west of Toronto. It has about 2000 inhabitants, and in some ways resembles an early stage of Toronto, when the latter contained about the same number of folk. (It is not of much significance that modern features such as electricity in Port Credit had no counterpart in the early stages of Toronto.) My second illustration is the town of Whitby (5000 inhabitants), which has grown up about 27 miles east of Toronto with much the same topography and hinterland as the other two lake settlements.

Port Credit was first settled in 1804 at the mouth of the Credit River (Fig. 18), and until 1845 the village was confined to the western bank. Almost all the houses were wooden, and were mostly two-storey gabled residences, of which several still survive. The next few decades were quite prosperous, and the little town had a considerable trade with U.S.A. in grain and timber (Photo 18). There was a busy port with quays, harbour works and a lighthouse. But tariff laws ruined the American grain trade, while

[13] If you wish to pronounce "Circumspice";
Don't rhyme it with "Mice" . . . but with "Mickey"!

all the timber was exhausted in the hinterland during the seventies. The storms around 1878 demolished the harbour works, and they were never rebuilt.

The railway station was placed on the east side of the estuary in 1855, and this led to the development of a new town nearer to the station, in which

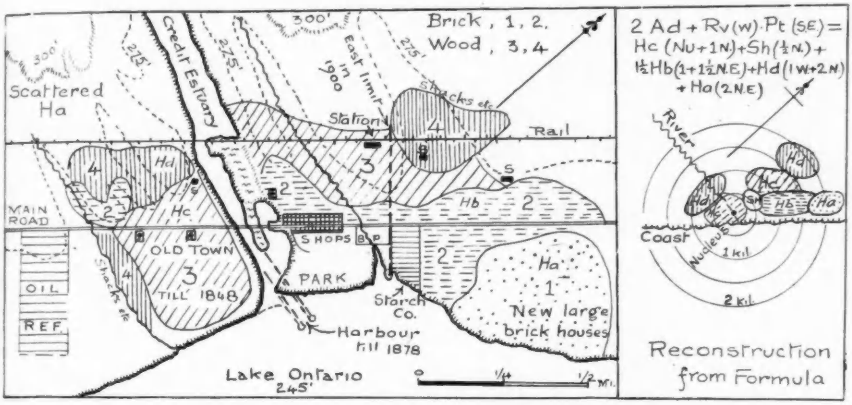


FIG. 18 (*left*).—A functional plan of the little town of Port Credit west of Toronto. Two contours are charted. The houses are in four classes; Ha, Hb, Hc, and Hd; the latter are mostly shacks.

FIG. 18 (*right*).—A plan of Port Credit reconstructed from the formula shown at the top of the figure. It is to be compared with the actual plan on the left.

PHOTO 18 (*left*).—The site of the former flourishing timber and grain port at the mouth of the Credit River. Today, though Port Credit is a good deal bigger, there is hardly a vestige left of the wharves and breakwater of 1875. The view is to the west.

PHOTO 18 (*right*).—One of the large frame houses which were typical of Port Credit about a century ago. Very few are now left.

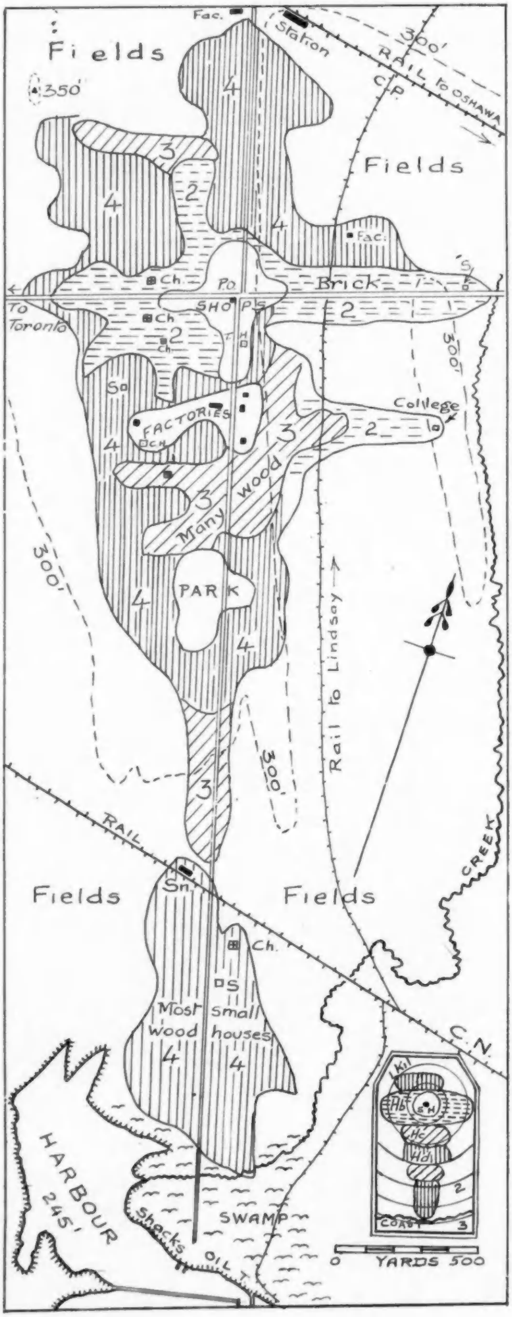


FIG. 19.—A functional plan of the little town of Whitby, 23 miles to the east of Toronto, and in a similar environment. The house-zones 1, 2, 3, 4, correspond to the zones Ha, Hb, Hc, Hd, in Figure 18. Inset is a reconstruction of the plan, derived from the formula given in the text. S is school, Ch is Church, Sn is station.

houses were built much more generally of brick. The population was about 450 in 1877, when the town contained three churches and three hotels; which is the same as today with a population almost 2000.

In 1900 the eastern portion equalled the western in area, but since that date there has been a great expansion to the east, as Figure 18 shows. Thus Port Credit developed in three stages; the old wooden town in the west till 1855 or so; the modern brick and wood town between the station and the little harbour till 1900; and after that date the newer portion right in the east.

There are two large industrial plants, each giving work to about 100 employees. The Starch Company commenced about 1889, and the large Oil Refinery in 1933. Today the town contains two schools and a High School, two banks and a large brick post office. The two rows of shops shown on the main street comprise 3 stores, 4 cafes, 3 realtors, 3 barbers, 2 butchers, a drug store, and a picture house.

The town pattern is *early mature,* since the older wooden houses were long ago replaced by brick near the shopping centre. The cheap wooden houses (Hd) have grown up on the margins, partly in response to the two large industrial plants. The very slow growth of the town has prevented the change of early homes (Hc) into the near-slums (Hd in part) as in Toronto. The group of large brick houses (Ha) in the southeast is not a natural outgrowth of Port Credit, but a sort of forest-suburb of Toronto.

It seems likely that the oldest western part of the town, consisting largely of wooden houses, gives us some idea of Toronto about 1840, though the latter was of course far larger (Photo 18). The addition of the newer eastern portion of the town with its numerous two-storey brick houses affords a picture which to some extent resembles Toronto in the seventies, before the development of special industrial sections in the city. The large houses (Ha) in the southeast, each surrounded with a large garden and often by small forest trees, are really outlying parts of Toronto; for their owners have in general not much cultural connection with Port Credit. However there are still many acres of farmland separating the little town from the metropolis. Not yet has it joined Long Branch and Mimico and become a mere satellite of Toronto.

A second example of a small town on the lake-shore near Toronto will show us the normal development of a town considerably larger than Port Credit. I have chosen Whitby, which is 22 miles east of the metropolis. Its site is much the same as at Port Credit, save that there is no river there, but only a small shallow bay which has been converted into a harbour by a breakwater across the mouth. The main cross-road follows along one of the usual broad north-south ridges of this coast. The 300-foot contour is shown on Figure 19. The swamps near the harbour have prevented house development near the lake. As at Port Credit, the days of shipping grain and timber have passed. Now oil is the chief import, and is stored in four tanks which

take the place of bygone elevators. A suburb south of the Canadian National railway survives from these earlier days. The total population is about 4500.

Whitby today has developed at the cross-roads, where the Toronto-Kingston corridor crosses the north-south road to the little port. The importance of Whitby as a port has almost vanished, but a number of small factories, dealing with brass-work, tanning, blankets, and canning, are adding to the vitality of the little agricultural town. The factories are not yet segregated, indeed several of them are not even on the various railways which meet at Whitby.

The pattern of the town shows the usual inner zone of shops at the cross-roads together with the post office and Town Hall. Outside this is the zone of larger houses, nearly all of brick (2 in Fig. 19), and here are found the chief churches. Beyond these zones the houses are on the whole built of wood, the nearer being usually two-storey and the distant houses one-storey. However a few larger houses are of course to be found in these zones also. A large Ladies' College is isolated on a ridge to the east of the town.

Although the town is twice as large as Port Credit it is not in quite such an advanced stage of urban development, mainly because the factories are smaller. The town may be described as in the *adolescent* stage, for there is no industrial zone and no zone of larger residences. Owing to the vicinity of Toronto, which tends to attract so much of the local trade, it does not seem likely that Whitby will soon advance much beyond this stage of development.

SECTION F

THE CLASSIFICATION OF TOWNS

There are innumerable types of towns scattered over the face of the earth, but it seems possible to clarify our ideas a little by "looking around" for stages in evolution as suggested earlier. The earliest settlements and towns seem to have developed in Mesopotamia or thereabouts. We can undoubtedly still find examples which differ little from those evolved many thousand years ago. They developed in turn into the crowded oriental towns of today. Perhaps one useful distinction is that between the oriental (or at any rate non-European) town and the *occidental* town of Europe or North America. This latter had its fairly well-defined evolution, which Geddes and Mumford have examined.[14] We may use their terms, which I have briefly defined in parentheses. Eotechnic (walled) towns, Baroque (palace) towns, Paleotechnic (industrial) towns, Neotechnic (planned) towns, Biotechnic (regional) towns, can all still be studied if we look far enough afield.

In accord with the Zones and Strata Concept the more primitive towns

[14] Patrick Geddes, *Cities in Evolution*, London, 1915.
Lewis Mumford, *Culture of Cities*, New York, 1938.

will be found near the margins, the more advanced near the centre of stimulus. Accordingly near New York and London we see the latest types, garden cities such as Radburn (N. J.) and Letchworth near London. These are perhaps *Neotechnic* in character. But the great majority of our occidental towns are *Paleotechnic*. Still, in quiet districts such as Carlsruhe or Versailles, we may gain some idea of the *Baroque* town of 200 years ago. Still further afield Old Carcassonne and Aigues Mortes in the south of France have changed little from the *Eotechnic* style. In Africa the *oriental* town still remains very little altered by a thousand years of progress elsewhere.

In the present address I am almost entirely concerned with the industrial (Paleotechnic) type of town. It is the subdivisions of this type with which we are immediately concerned. I have already suggested that most cities of our age and culture pass through a number of similar stages. It should be the duty of the urban geographer to integrate his data in this research, much as W. M. Davis did in his classic studies of the evolution of landscapes. But our problem will be more difficult, since our agent—determining the evolution of cities—is *man* the irrational, while the agent in his problem was ever-logical *Nature*.

The matter may well be set out in a table as follows:

Classes of Towns; Subdivisions of Paleotechnic Towns

Evolution of towns	Occidental or Oriental.
Occidental towns	Eotechnic, Baroque, Paleotechnic, Neotechnic, Biotechnic.
Paleotechnic stages	Infantile, Juvenile, Adolescent, Mature, Senile.
Infantile towns (In)	Haphazard distribution of houses and shops, no factories.
Juvenile towns (Ju)	Differentiation into zones (of houses and shops) starts.
Adolescent (Ad)	Scattered factories, no definite zone of 'Ha' houses.
Early Mature (Er)	Residence zones fairly defined, no segregation of factories.
Mature (Ma)	Four zones of houses, separate commercial and industrial areas.
Late Mature (La)	Indications of advance to biotechnic development.
Senile (Se)	Large areas of town abandoned, remainder stagnant.

Formulae for towns

In a genetic approach to urban geography we are chiefly interested in the town as an evolving organism. We want to know its present pattern, how that developed, and where and why the town started. For the present we can ignore the street plan, the source of its trade, the extent of its umland, and a vast number of other interesting features of a city. I see the city as a series of zones, expanding from the original nucleus, and usually conditioned in its growth by the surrounding environment, unless we are dealing with a city of the plains. Several features therefore seem to be essential in our proposed formulae. We should know something as to the original site or

nucleus; as to the reason for its founding; as to its growth with respect to the nucleus. As regards the zones, we should know their width and position. Further we might well include some clue to its stage of development, and of course a reference to the total population.

In 1938 I read a paper before this Association dealing with a number of towns in the Italian region of the Trentino. There I gave a preliminary description of formulae, including many of these terms. Since that time I have been trying to apply the same technique to American and other towns. I feel sure that such research is worth while, and equally sure that the technique which is suggested herewith will be greatly improved upon as time goes on.

Abbreviations used in the formulae

Directions. North (N.), Northeast (N.E.), etc.; all from the nucleus (Nu).
Stage of Development. Infantile (In), Juvenile (Ju), Adolescent (Ad), Mature (Ma), Senile (Se), Nucleus (Nu).
Site of town. Capital (Cp), Fan (Fn), Fort (Ft), Mountain (Mt), Mining (Mn), Pass (Ps), Oasis (Oa), Railway (Ry), Rail-crossing (Rc), Road (Rd), River (Rv).
Population. Figures represent thousands.
Distances of zones, etc. Figures represent kilometres.
Zones. Apartments (Ap), Factories (Fc).
Houses—Largest (mansions) (Ha); Large (Hb); Small (Hc); Shacks or decayed houses (Hd).
Offices (Of); Shops (Sh); Stores, large (Sa).
Equation order. Population, Status, Site . . . . on the left.
Zones, proceeding outwards . . . . on the right.

Let us run over the description of Port Credit and see how our formula would work out (Fig. 18). The population is about 2000. This would be represented by "2" (the number of thousands) in the formula. The town was originally a lake-port on a little river. This is indicated by Rv Pt. With regard to the *nucleus,* the river is to the west, and the lake (or sea) to the southeast. So our formula becomes "Rv(W.)Pt(S.E.)." The stage of development is between adolescent and early mature. Since it is so small a town, and the mansions are linked to Toronto rather than to Port Credit, it would seem to be adolescent (Ad). This general portion of the formula forms the *left* side of our equation.

Now we may turn to the particular zones, which appear in the *right-hand* side of the equation. The present shopping centre has been shifted from the original nucleus, about ½ kilometre to the north. Thus the shop-zone appears as "Sh(½N.)." The house-zones should be given in order from the centre of the town outwards. Thus the second-class houses (Hb) form a zone with

a centre about one kilometre northeast of the nucleus, *i.e.*, Hb(1N.E.). Then comes Hc, the original large wooden houses which still surround the nucleus, but also cover a zone one kilometre to the north, *i.e.*, Hc(Nu + 1N.). The shacks Hd are found one kilometre west of the nucleus, and also 2 kilometres north and so we get Hd(1W. + 2N.). Finally the large brick houses (not quite mansions) represent class Ha, and are being built 2 kilometres northeast of the nucleus, *i.e.*, Ha(2N.E.).

The total formula comprises two sides of an equation as follows:

$$2\,\mathrm{Ad} + \mathrm{Rv(W.)\,Pt(S.E.)} = \mathrm{Sh}(\tfrac{1}{2}\mathrm{N.}) + 1\tfrac{1}{2}\mathrm{Hb(1N.E.)} + \mathrm{Hc(Nu + 1N.)} + \mathrm{Hd(1W. + 2N.)} + \mathrm{Ha(2N.E.)}$$

The factories are not arranged in a zone, hence are not mentioned in the formula; but the presence of a few factories may be gathered from the fact that the town is adolescent.

To reconstruct a rough plan from the formula, we proceed as follows (see the inset in Fig. 18). A large dot is placed for the nucleus, and concentric circles are drawn with radii increasing by half kilometres. We can add the river coming in from the west, and the lake shore along the south. The distance indices (in the brackets) show the position of the centre of a zone. Thus the shops can be placed half a kilometre to the north of the nucleus. If reasonable patches or zones be drawn contiguous to each other, in accord with the indices, we obtain a plan which is quite close to the actual pattern of Port Credit, and gives us almost all the characteristic features of the settlement.

The formula for Whitby can be obtained in the same fashion. It comes out somewhat as follows:

$$4.5\,\mathrm{Ad} + \mathrm{CrPt(3S.)} = \mathrm{Sh(Nu)} + \mathrm{Hb}(\tfrac{1}{2}\mathrm{E.} + \tfrac{1}{2}\mathrm{W.}) + \mathrm{Hc}(\tfrac{1}{2}\mathrm{S.} + 1\tfrac{1}{2}\mathrm{S.}) + \mathrm{Hd}(\tfrac{1}{2}\mathrm{N.} + 1\mathrm{S.} + 2\tfrac{1}{2}\mathrm{S.})$$

We may interpret this as follows. A small town in the adolescent stage with a population of 4,500 has developed at a cross-roads with a little port 3 kilometres to the south. On the right of the equation we find the zones; *i.e.*, the shops at the nucleus, with three house-zones at various distances as shown in the brackets. For instance there are three separate areas of Hd (smallest houses): at one-half kilometre north, one kilometre south, and again at $2\frac{1}{2}$ kilometres south. A reconstruction from the formula is given as an inset in Figure 19. It clearly gives us a fair picture of the actual plan of Whitby.

Formulae for Toronto. Turning now to the four diagrams given in Figure 16 we may reduce the zones to formulae somewhat as follows:

Toronto was primarily a harbour, and the sandy hook (shown in Fig. 15) was probably more vital in 1793 than it would be now. For instance, such important ports as Chicago and Gary have been developed where natural

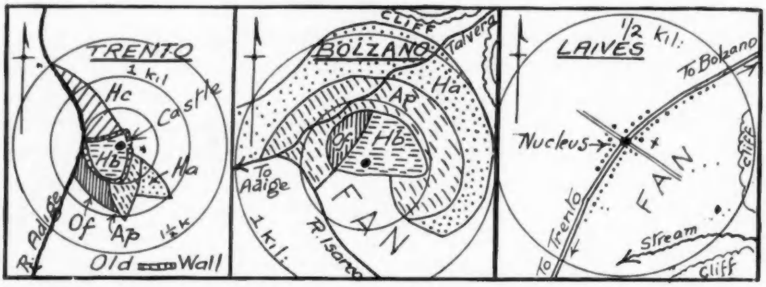


FIG. 20.—Three towns in the Italian Alps illustrating Eotechnic origins. Formulae are given in the text. The circles are half a kilometre apart, with the nucleus as centre.

harbours were almost non-existent. (Here we may hear the possibilists cheering!!) But as time went on the political aspects became of great importance. Hence we must indicate that Toronto is a Capital (Cp) in our formula. Obviously each of the four maps of Toronto (at different periods) has a different formula; but the nucleus is always as indicated by the little circle in the earliest map.

For the town in 1818 the formula is

1.2 In + Pt(S.)Cp = Hd(Nu) + Hb(2W.)

For the town in 1842 we get

20 Ju + Pt(S.)Cp = Hc(Nu + 2W.) + Sh(1W.) + Hb(2N.W. + N.E.)

For the town in 1885

120 Er + Pt(S.)Cp = Hd(Nu + 2W.) + Of(1W.) + Hc(N. + 3W.) + Hb(3N. + 4N.W. + 4W.) + Ha(2N. + 5W.)

For the present town in 1940, the formula is naturally a long one.

890 Ma + Pt(S.)Cp = 5Hd(Nu + 1E. + 3W.) + Of(1W.) + Fc(1½S.E. + 4W. + 6N.W.) + Hc[7(2N.E. + 3N.W.) + 6N.W.] + Hb(4E. + 4N. + 7N.W.) + Ha(3N. + 6N.W. + 9N.W.)

In this formula the area covered by third-class houses (Hc) is in two definite belts. These are suggested by the double brackets in the formula. Obviously other details may be added to the formula. For instance apartment houses form a characteristic zone (for which we may use the abbreviation "*Apa-zo*") five kilometres to the northwest of the original nucleus. This could be shown as "Ap(5N.W.)." Since no figure appears outside the "direction" bracket, we should plot it as a patch less than kilometre wide. We may use the contraction "*Hou-zo*" for the characteristic house-zones, and so for the other leading features which determine the character of the town and formula.

The technique will become more familiar if we consider a set of quite

different settlements which I investigated in 1938 in Italy. I give simplified plans of three of these in Figure 20, as well as the formulae deduced therefrom. Trento is a town which originated in Roman times. The present town had as a nucleus the medieval castle (Ft, *i.e.*, Fort) which commanded the wide glacial trough of the Adige River.[15] It was, till lately, a typical walled (Eotechnic) town; while the modern town is of the adolescent Paleotechnic type (Photo 19). Its present population is about 60,000. Hence

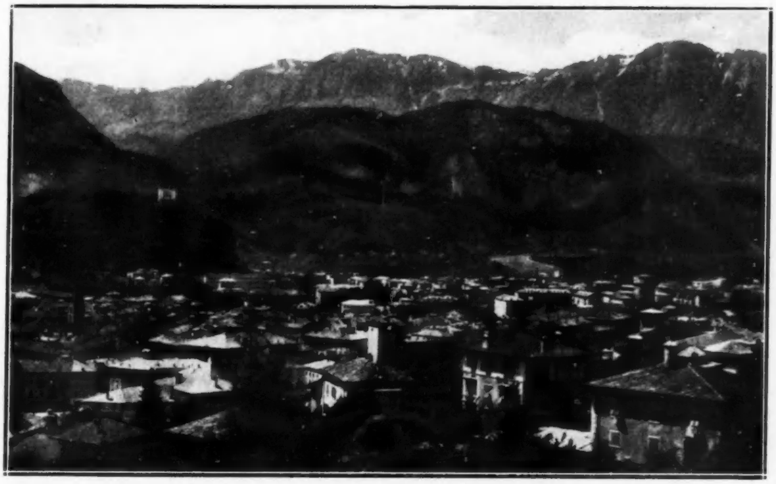


PHOTO 19.—The town of Trento in the Alpine portion of Italy. Notice the Adige River below the great cliffs, and the ancient Castle at the right of the older part of the town, which is now surrounded by modern buildings. The fortified bluff with the Battista Tomb appears at the left. The view is toward the northwest.

the left half of our "formula equation" comes out

$$60\ (\mathrm{Eo} + \mathrm{Ad}) + \mathrm{Rv}(1\mathrm{W.})\mathrm{Ft}(\mathrm{Nu})$$

The zones of dwellings in Trento are somewhat complicated by the fact that the industrial town (Ad) has spread out beyond the medieval town (Eo). If we draw the half kilometre circles about the nucleus, we summarize the "*Hou-zo*" as follows (on the right of the equation).

$$\mathrm{Hb}(\tfrac{1}{2}\mathrm{S.W.}) + 2\mathrm{Ap}(\mathrm{S.}) + \mathrm{Ha}(\mathrm{S.E.}) + \mathrm{Of}(1\tfrac{1}{2}\mathrm{S.W.}) + \mathrm{Hc}(1\tfrac{1}{2}\mathrm{N.W.})$$

There is no well-developed belt of industries, though a few factories occur in the northeast. A modernist tourist quarter occurs in the heart of the Hc zone; but is too small to be represented in the formula.

[15] "Trento to the Reschen Pass," Griffith Taylor. *Geog. Rev.*, 30 (April, 1940).

Bolzano may be taken as the second example (Fig. 20). It is situated near the junction (Jn) of the Adige and the Isarco (which rises in the Brenner Pass). It is built on the large detrital fan of the Talvera Torrent. Like Trento it is half Eotechnic and half Paleotechnic in pattern. The "Hou-zo" are perhaps more regular in Bolzano, and the formula is as follows:

$$40\,(\mathrm{Eo}+\mathrm{Ad})+\mathrm{FnJn}(1\tfrac{1}{2}\mathrm{S.W.})=\mathrm{Hc}(\mathrm{Nu})+\mathrm{Of}(\tfrac{1}{4}\mathrm{S.W.})+ \mathrm{Ap}(\tfrac{1}{2}\mathrm{W.}+\tfrac{1}{2}\mathrm{N.E.})+\mathrm{Ha}(1\mathrm{W.}+1\mathrm{N.E.})$$

The little village of Laives with a population of about 500 has grown up on a fan about 8 miles south of Bolzano (Fig. 20). It is less than one kilometre across (Photo 20). Here we find merely a series of about 60

PHOTO 20.—Laives, a small notch-village built on an alluvial fan in the Adige Corridor about 8 miles south of Bolzano. The vineyards of Laives appear in the foreground. The view is looking south.

houses along the main road, mostly large and well-built and standing in their own vineyards. There is no differentiation into zones, so that it is in the infantile stage, and the formula is simple. For Laives:

$$0.5\ \mathrm{InFn}=\mathrm{Hb}(\tfrac{1}{4}\mathrm{N.E.}+\tfrac{1}{4}\mathrm{S.W.})$$

Enough examples have been given for the reader to realise that it is quite possible to summarise in a one-line formula the salient features of a town. The general characters (*i.e.*, site and status) appear on the left of the formula equation, the zonal details on the right. I have not attempted to

cover any but paleotechnic towns (*i.e.*, the usual occidental industrial towns); but of those referred to earlier in this address, Pekin is oriental with some senile characters; while Biskra is partly paleotechnic and partly oriental. Urandanji, McMurray, and Waterways are infantile. Canberra with its cobweb patterns and its isolated communities is neotechnic, approaching the biotechnic town; but lack of space forbids my discussing any but the paleotechnic type of town.

Section G

POSSIBILISM APPLIED TO RACE, NATION AND CITY

As most of my readers know, I have always been a rather definite environmentalist. In concluding this address, I wish to consider whether determinism or possibilism is of more importance in connection with the three types of human groups which I have studied with some thoroughness. In my book on the major human races (*Environment, Race and Migration, cit.*), I advanced data which seemed to me to prove that *in the remote past* races had actually differentiated as the result of environmental control and environmental changes. In those remote periods (certainly prior to 20,000 years ago) man migrated primarily for the same reasons as the higher mammals. He exercised little choice, and a geographer in those days would almost certainly have been a whole-hearted determinist! Thus the major human clusters in the far past were certainly chiefly controlled by environment.

In the later *historic* period, the major migrations of earlier times, and the mass-migrations of today, seem to me to illustrate the push from the homeland combined with the pull of the pioneer lands. If a man experiences neither push nor pull, he stays at home. A study of the environmental controls of various parts of the world, and the way in which these may affect migrations of the future was published by the writer in 1922.[16]

Turning now to the smaller groups such as the *nations* of Europe, I studied the reasons for the distributions of cultures, towns and populations in that continent. It seemed to me clear than those anthropomorphic servants of the environment, King Coal, King Frost, and King Drought, were far more important in producing the population-pattern of saturated Europe than were the actions and orders of men, from Charlemagne and Napoleon downward. The widespread changes due to human orders (*i.e.*, "choice") produced *permanent* results only if they were in line with environmental control, but if not, such changes were soon dissipated or annulled. (*Environment and Nation, cit.*).

In a general sense this is true of major cultures as of major populations. Roumanian culture has persisted chiefly owing to the ever-present refuge

[16] "Distribution of Future White Settlement" *Geog. Rev.*, 12 (July, 1922).

given by the southern Carpathian plateaux. Italian culture is the creation of the northern Alpine barrier. Swiss culture clings to its Alpine refuge. French culture is Roman culture, bounded by the Rhine barrier and the Rhine defence. German culture is in large part the non-Roman culture preserved in the thick forests of the west German plain. British culture is due to her sea-girt island.

Yet it is clear to the impartial student that as the human clusters become smaller, the general effects of environmental control on the unit become intermingled with rather special results due to man himself. Thousands of worthy Americans live in Indiana today, partly because (as the possibilists say) the ancestral emigrants "chose" to leave England. But what seems an even more potent reason to a determinist is that the environment favoured large and prosperous families. Other quite similar emigrants, in the distant past, chose to migrate to the West Indies, but their numbers have remained negligible; for environmental reasons as I see it.

Ratzel was the great German protagonist of determinism; and I have often wondered if the growth of Possibilism in France was not in some measure due to a national antipathy to all things German. Indeed I have seen the statement that Haushofer's modern *Geopolitics* (extreme Imperialism) is a logical outcome of Ratzel's *Determinism*. Could not one as well derive the many dangerous schisms in French politics from the individualism of French *Possibilism!* I illustrate the effect of environment upon one's philosophic creed by an exaggerated reference to certain American geographers.

I ask you to pity our unfortunate colleagues who have been brought up in that part of the Eastern States whimsically called the "Middle West." The region between Chicago, Omaha and St. Louis has so uniform a climate and so level a topography that major environmental controls are necessarily almost lacking. Moreover the general conditions were so favourable to settlement (at any rate in the early days) that wise, medium, or foolish, choices of settlement-technicques all resulted in a fair measure of prosperity. How could our worthy Middle West colleagues escape becoming Possibilists! I said I was exaggerating, but I do firmly believe that on some nine-tenths of the earth's surface man's choice is so limited as to be almost negligible. There is usually only *one* way to exploit the terrain most successfully, and it can only be ascertained by lengthy and thorough investigation of the environment.

The third of our categories concerns *town and cities*. Here we are dealing with man-made structures, and it is evident that man can choose every detail of the object of his own creating. Here I grant that possibilism plays a role of greater importance that does the environment. Yet even in the

innumerable towns of the fertile plains of the Middle West—where the chief feature of a suburb is said to depend on which side of the railway it lies—even in these checkerboard towns there are many problems which depend very largely on the environment.

I often wonder why there is so much opposition by geographers to the concept of environmental control. One would think little of a doctor who spent ten years studying medicine, and then practised according to the tenets of Mary Baker Eddy. Or of a lawyer who summed up his studies in the words of Bumble the Beadle, and loudly proclaimed that the "Law is an Ass."

A student of the widespread sterile areas in the world inevitably tends to become somewhat of a determinist. It is precisely because the student of Urban Geography is engaged in the field which is least affected by environmental control that I have dwelt on possibilism in this address. Man, like every other living creature, is a parasite on the surface of the earth. He exists by exploiting the environment. For me, the answer to our controversy (possibilism *versus* determinism) is suggested by a modification of the old proverb, "Nature pays the piper, and, in most parts of the world, she also calls the tune."

A dozen years ago I was in Shanghai, and made some study of Sun Yat Sen's book "International Development of China." I was much impressed to find that this book, by the leader of the young Republican Party of China, was largely a study of the economic geography of that country. We see the same thing in the plans of the Soviet Union. Some day our discipline will progress beyond its present stage of the Cinderella of the sciences. Cannot we geographers study the world to such purpose that we shall in time be accepted as a body well suited to guide the nation along the paths of material and cultural progress? Can we not all strive to become Nation-Planners?[17]

May the day come when the public will say of every careful student of our discipline, "He has studied material progress all over the world. He knows the possibilities, and can interpret our environment to our best benefit. In a word he is a competent geographer. We must listen to him."

Acknowledgements. I have to thank a number of people for supplying me with data for this address. Among these are Kenneth Binns (Canberra), G. Gordon (Port Credit), Nadine Hooper (Toronto), A. Pollan (Boston), F. T. Rowe (Whitby), and George Tatham (Toronto).

University of Toronto
December, 1941.

[17] "The Geographer's Aid in Nation-Planning," Griffith Taylor, *Scot. Geog. Mag.*, Jan.-March, 1932.

Lags and Ranges of Temperature in Hawaii

STEPHEN B. JONES

In this paper, temperature data for Hawaii are analyzed with respect to (a) annual range of temperature, (b) lag of the seasons after the solstices, (c) shape of the annual temperature curve, and (d) daily range of temperature and its annual variation.

Each of the Hawaiian Islands, though small in area,[1] shows marked temperature regions. Moreover, there is similarity in the regionality of all the islands. This regionality arises from the mountainous character of the islands and the regularity of the winds. The extreme types of regions are the cloudy, rainy, windward (northeast) slopes and the sunny, dry, leeward coast. In the former, low annual and daily ranges and long seasonal lags prevail. In the latter, high ranges and short lags dominate.

This study is empirical in method. It has not led to quantitative relationships between lag and range and such factors as cloud, rain, and exposure to wind. Qualitative estimation of their efficacy has been possible in some cases. It appears that the several controls are to some extent interchangeable. Turbulent winds may offset lack of cloud, for example. Instrumental data which clearly separate the several influences are not yet available.

The basic data for this study are temperature measurements for forty-three United States Weather Bureau stations, mostly of the cooperative type (Table I and Fig. 1).[2] This number includes all stations in the Hawaiian Islands which had, in 1935, temperature records twenty or more years in length. Means through that year were available in manuscript at the Honolulu office of the Weather Bureau. Shorter records have been used, with caution, in a few cases.

The writer wishes to acknowledge the unfailing help of the staff of the Honolulu office of the Weather Bureau, and especially of Mr. L. W. Browne, climatologist. Thanks are due Mr. Harry Tanaka, University of Hawaii,

[1] The areas of the four largest islands are as follows: Hawaii, 4030 square miles; Maui, 728; Oahu, 604; Kauai, 555.

[2] All temperatures in this paper are Fahrenheit. Ocean temperatures are from U. S. Weather Bureau: *Atlas of Climatic Charts of the Oceans*, Washington, 1938, Charts 115–126. Wind roses (Fig. 2) are from recent U. S. Hydrographic Office pilot charts.

for able assistance in compilation of data, and Professors Harry Clements, H. S. Palmer, and J. C. Ripperton, University of Hawaii, Mr. Robert G. Stone, Blue Hill Observatory, and Professor John Leighly, University of California, for valuable constructive suggestions.

APPROACH TO THE STUDY

The amplitude, phase, and shape of the temperature curve for a given station depend on the immediate environment and on the source and history of the air which moves past. Of primary importance is the well-known contrast in the heat economy of land and water. The storage of heat in water, mainly by circulation, coupled with the high specific heat of that substance, reduces ranges and increases lags. Calm water heats in a relatively thin layer in summer, but the cooling of winter involves the convectional overturn of a thicker layer. The summer peak of surface temperature in calm water should therefore come soon after the peak of insolation, while the winter trough should be flattened and show greater lag. Forced circulation, by waves for example, might obscure the preceding effect, especially in turbulent trade-wind seas where seasonal changes of temperature are small. These characteristics will be imparted to maritime air but may be lost during the passage of that air to land stations.

In a paper embodying a presentation of this concept of heat turnover,[3] Leighly calls attention to the fact that climatological temperature data are obtained from a shallow layer, the "climatologic air," which of itself has small heat capacity and is greatly affected by the surface beneath and the free air above. If the surface beneath were alone responsible for climatologic air temperatures there would be no marine climates except at sea; all land climates would be continental. Where climatologic air is stagnant, as in winter in enclosed valleys, and if the free air is clear, temperatures relatively continental may prevail not far from the sea. Persistent offshore winds have a similar effect. Leighly found very short winter lags in the narrow valleys of the California Coast Ranges. One of the least marine of Hawaiian climates (Waialua, Oahu—Fig. 1) is found on a coast protected to some extent from both trade and southerly winds.

The simplest way for long lags and low ranges to dominate at land stations is for sea air to sweep directly past the thermometers. Leighly has shown that such direct marine influence diminishes very quickly inland. Similar rapid declines in marine influence appear at dry localities near

[3] John Leighly: The Extremes of the Annual Temperature March with Particular Reference to California, *University of California Publications in Geography*, vol. 6, 1938, pp. 191–234.

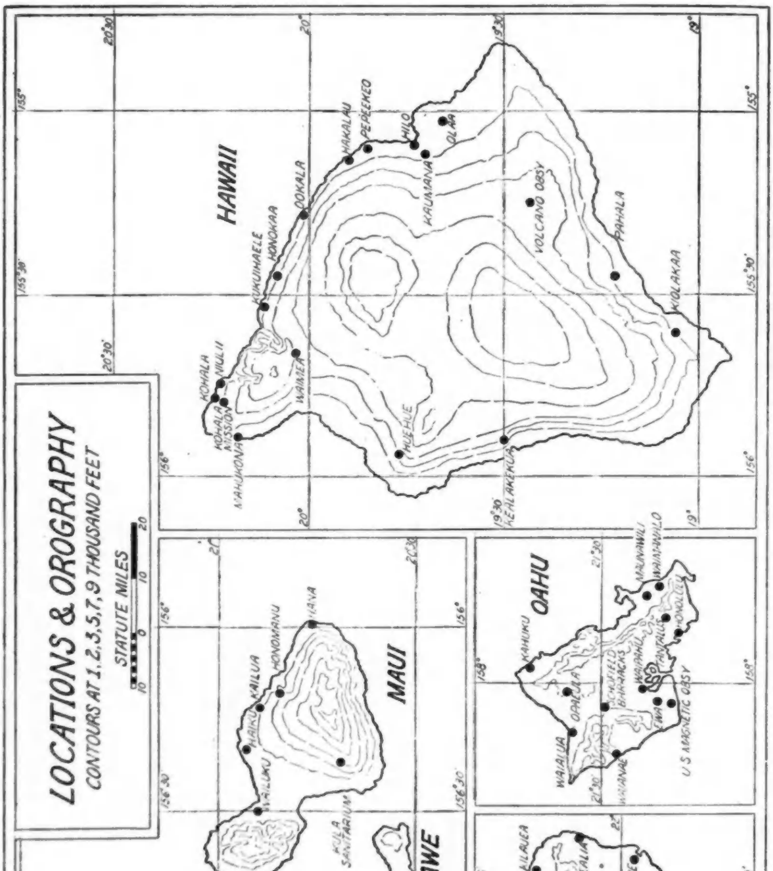


FIG. 1.—Locations and orography. Contours at 1000, 2000, 3000, 5000, 7000, and 9000 feet.

TABLE I

Basic Climatological Data for Stations Used in the Study

	Elevation (feet)	Years of temp. record (to 1935)	Mean annual temp.	Rainfall (inches)
KAUAI				
1 Kilauea	320	31	72.7	68
2 Kealia	11	31	74.8	40
3 Lihue	207	31	73.0	53
4 Koloa	241	31	73.1	64
5 Eleele	150	19	74.0	29
6 Makaweli	140	31	74.7	22
7 Mana	30	31	73.8	22
OAHU				
8 Kahuku	25	31	74.6	37
9 Waimanalo	25	31	75.4	43
10 Maunawili Ranch	250	31	72.6	82
11 Tantalus	1360	31	69.1	100
12 Opaeula	1100	31	70.2	58
13 Honolulu	111	32	74.6	25
14 Waialua	32	31	73.2	31
15 Schofield Barracks	892	27	70.9	39
16 Waipahu	60	31	74.2	25
17 Ewa	42	31	73.8	21
18 U. S. Magnetic Obs'y	35	31	74.9	20
19 Waianae	10	31	75.8	20
MOLOKAI				
20 Molokai Ranch	800	31	71.9	32
MAUI				
21 Hana	200	29	73.9	75
22 Honomanu	1600	31	66.5	232
23 Kailua	700	31	70.4	129
24 Haiku	530	20	72.8	69
25 Wailuku	200	31	74.4	29
26 Kula Sanatorium	3004	20	64.0	32
27 Kaanapali	12	31	75.3	18
HAWAII				
28 Waimea	2669	29	63.8	43
29 Mahukona	11	24	77.6	14
30 Kohala	309	31	72.5	56
31 Kohala Mission	537	31	72.2	58
32 Niulii	85	31	73.6	57
33 Kukuihaele	275	20	72.4	68
34 Honokaa	455	31	72.1	68
35 Ookala	425	31	72.6	115
36 Hakalau	175	31	72.4	137
37 Pepeekeo	100	31	73.0	128
38 Hilo	40	31	72.6	137
39 Kaumana	500	27	70.0	165
40 Olaa	225	31	72.4	141
41 Volcano Obs'y	3979	23	60.8	95
42 Pahala	850	31	71.2	43
43 Kiolakaa	1000	20	70.9	53

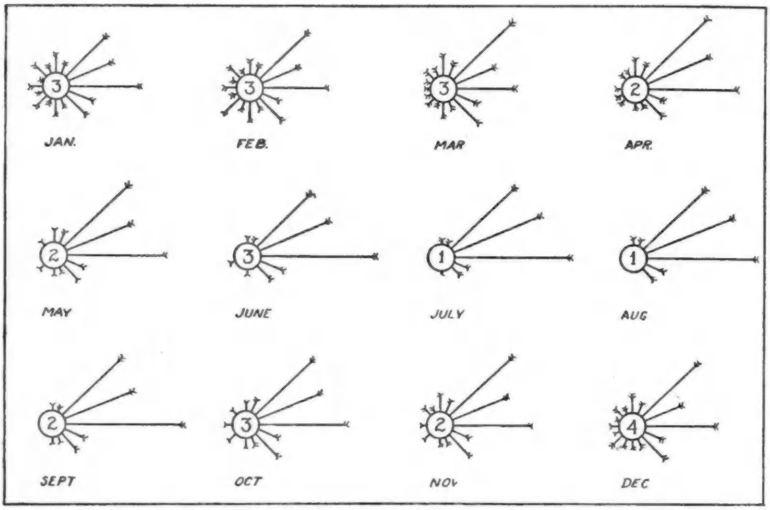


FIG. 2.—Wind roses for the ocean near Hawaii. From U. S. Hydrographic Office pilot charts.

windward shores in Hawaii (*e.g.*, Kealia, Kauai, and Waimanalo, Oahu). Turbulence, by preventing the formation of a stable surface layer, prolongs the inland extension of marine effects. Thermal turbulence is at maximum in summer and hence tends to give greater lags for the warm season than for the cold. In the tropics there is usually some turbulence during the day, even in the coolest weather, but the more frequent formation of a cool surface layer at night in winter is important in Hawaii. Mechanical turbulence is great in mountain passes, important on peaks and ridges and in valleys parallel to the air flow, and low in protected basins. Leighly found long lags in the windy Cajon Pass area of Southern California. The long lags and low annual range at Waimea, Hawaii, to be described later, may likewise be due to location in a mountain gap.

Several other factors may influence the shape of the temperature curve. Seasonal changes of wind, bringing different kinds of air, are important. Cloud, fog, and rain may subdue land effects on maritime air. Cloud and fog may reduce ranges and produce abnormally early or late extremes, for daily or annual periods. Hawaii provides many examples. Rain cools the climatologic air both directly and upon evaporating. Leighly, writing of "Sunny California," discusses coastal fog but attributes most interior peculiarities of seasonal lag to turbulence or stagnation. In Hawaii, cloud and

rain play important parts. It is possible, too, that long winter lags in the California Sierra Nevada come from cloud and snow cover as well as from turbulent mountain winds. Atmospheric turbidity such as dust or salt haze may be important in some localities.

ANNUAL RANGES OF TEMPERATURE IN HAWAII

For the present purpose, "annual range" is defined as the difference between the means of the extreme months.

The main controls—latitude and continentality—are well known. As would be expected, tropical, oceanic islands show very small annual ranges. The greatest range for a long-record station in Hawaii is 8.5 degrees (U. S. Magnetic Observatory, Oahu, Fig. 3). The smallest is 4.4 degrees (Waimea, Hawaii), or approximately half as much. The air over the ocean about the islands shows an annual range of roughly five degrees. By way of contrast, annual ranges of twenty or thirty degrees are found in similar latitudes in the Sahara.

Many Hawaiian stations have annual ranges little different from those in the air over the neighboring oceans (Fig. 3). Most of the low-range stations are to be found on the windward coasts of Hawaii and Maui, in areas of heavy rainfall. The exceptions to this rule are very instructive. The much smaller range at Tantalus, Oahu, than at Waimanalo, a few miles east, shows that proximity to a windward coast is not the critical factor. Tantalus, though to leeward of the mountain crest (Fig. 1), is very rainy, while Waimanalo is dry. But heavy rainfall is not essential for low annual range. Moderately wet Kiolakaa and Waimea, Hawaii, and Haiku, Maui, have low ranges. Turbulent wind may be a major factor. Waimea is in a mountain gap, the other two on mountain shoulders. Waimea and Haiku have many days with rain[4] and hence probably considerable cloud. Kiolakaa has fewer than half of its days with rain, yet its annual range is the same as that of rainy Olaa, only half a degree of latitude farther north. One low-range station, Kealakekua, on leeward Hawaii, is neither windy nor, for the tropics, excessively rainy. It receives, however, regular afternoon clouds in summer through convectional sea breezes.

Most high-range stations are on sunny lee slopes, but there are several exceptions. On Kauai, there is little difference between Mana, with only 53 rainy days a year, and Lihue, with moderate rainfall but 238 rainy days. Two fairly dry but windward stations, Kealia (Kauai) and Waimanalo (Oahu), have annual ranges of nearly eight degrees. High annual range

[4] Days with measurable rain, shown in Figure 3, conform to the usual definition; that is, days with 0.01 inch or more of precipitation. There need be no close correlation with rainfall or cloudiness.

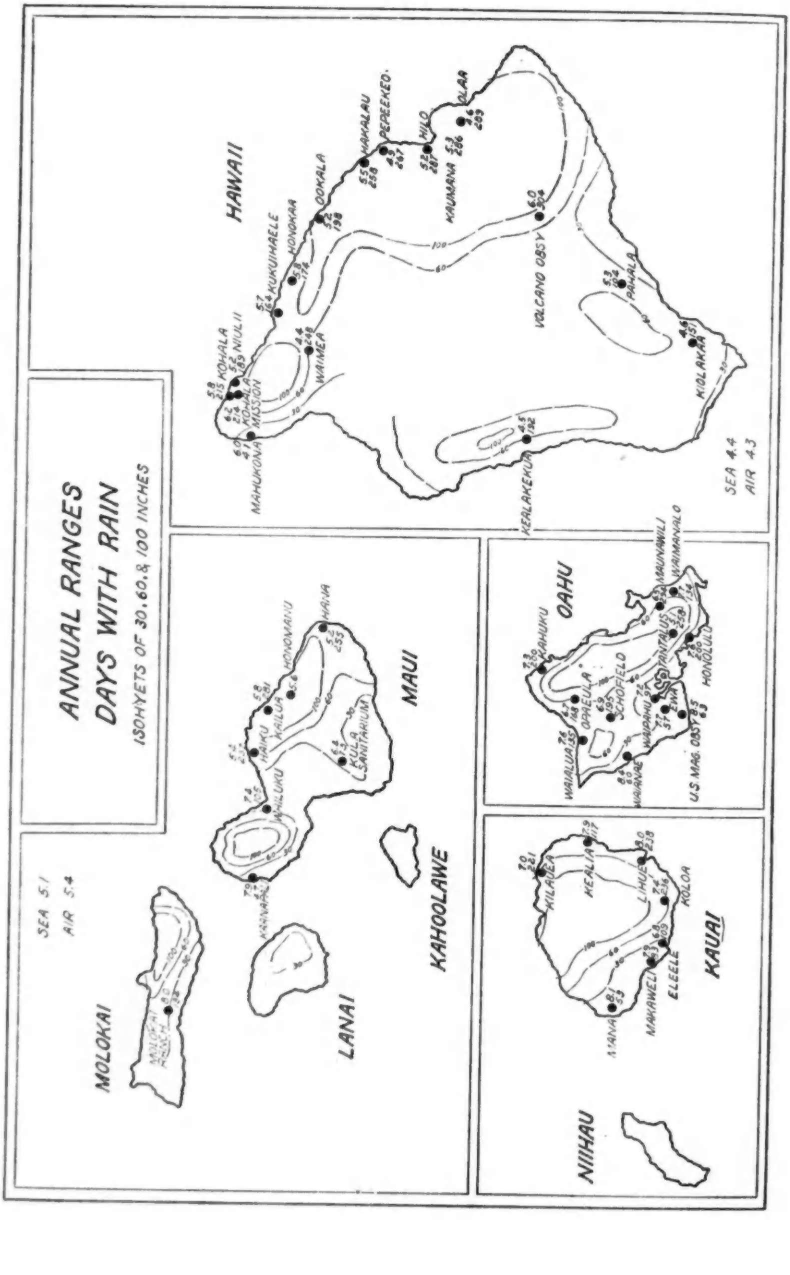

ANNUAL RANGES
DAYS WITH RAIN
ISOHYETS OF 30, 60, & 100 INCHES
HAWAII
SEA 4.4
AIR 4.3
MAUI
MOLOKAI
LANAI
KAHOOLAWE
SEA 5.1
AIR 5.4
OAHU
KAUAI
NIIHAU

FIG. 3.—Annual range of temperature; number of rainy days; isohyets of 30, 60, and 100 inches.

is thus compatible with moderate rain, many rainy days, and windward location, provided clouds or strong winds do not prevail. Small land features that may permit less turbulent air to surround the instruments are present at Lihue and Kealia. Only low dunes lie to windward of Waimanalo, but a level site and a mountain wall two miles to leeward may create some stagnation of climatologic air.

Notable is the relatively low range at Mahukona, Hawaii—one of the driest stations and definitely the hottest in the islands (Table I). The annual range is about the same as in rainy windward Kohala. The high mean temperature may be due to a foehn effect. The low annual range, for such a dry station, may be traced to the factor that permits a foehn—the small size and moderate altitude of the Kohala peninsula. Strong trade winds blow across it, sweeping Mahukona. Mahukona has leeward drought and warmth, but not leeward shelter from wind. The greater annual range of Kaanapali, a dry, hot station on leeward Maui, only a degree of latitude farther north, supports this explanation. Calm may prevail at Kaanapali

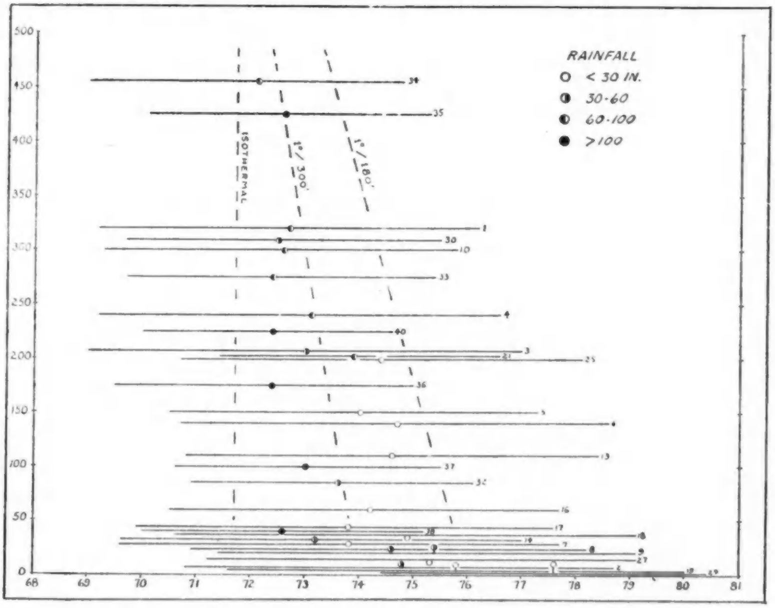


FIG. 4.—Mean annual temperatures and ranges for stations below 500 feet.

while strong trade winds sweep to north and south about the high West Maui mountains.

Are the differences in annual ranges in the Hawaiian Islands the result of cooler summers at low-range stations, warmer winters, or both? To what extent are low ranges due to truncation of one or both extremes of the annual temperature curve? The first question is answered by Figure 4. The mean temperatures of all stations below 500 feet have been plotted, with lines indicating annual range. The minima, with the exception of Mahukona (29) show relatively little variation with altitude. A generalized lapse rate through the maxima is much steeper. In general, low-range stations have low means and are slightly cooler in winter and much cooler in summer than are high-range stations.

The second question will be answered in a later section (The Shape of the Annual Temperature Curve).

Long-period temperature data for oceanic islands in latitudes comparable to Hawaii are not abundant. Data for eight stations were obtained from publications of Clayton, Reed, and Schott.[5] In Table II some of them have been matched as well as possible with Hawaiian stations of similar latitude and rainfall. It appears that, latitude for latitude and rainfall for rainfall, southern hemisphere stations show greater annual ranges. This might follow from the ellipticity of the earth's orbit, which gives perihelion during southern summer (*cf.* insolation curves, Fig. 11 below). However, most of the stations available for comparison are not entirely free from continental influences. Avarua and Alofi, the two least apt to be affected by large land masses, show ranges only slightly greater than those for Hawaiian stations of similar latitude.

LAG OF THE SEASONS AFTER THE SOLSTICES

That hardy perennial, the groundhog myth, shows that the delay of the seasons has long interested mankind, but quantitative studies of this phenomenon have been relatively few. References to literature are cited in Leighly's paper on California. Leighly himself has contributed a graphical device for finding the dates of highest and lowest mean temperatures from monthly means. The method assumes that the annual temperature curve is sinusoidal near the extremes. Leighly has applied his method with inter-

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[5] H. H. Clayton: *World Weather Records, Smithsonian Miscellaneous Collection*, vol. 79, Washington, 1927 and vol. 90, Washington, 1934.

W. W. Reed: Climatological Data for the Tropical Islands of the Pacific Ocean (Oceania), *Monthly Weather Review Supplement* 28, 1927.

G. Schott: Klimakunde der Südsee-Inseln, *Handbuch der Klimatologie*, Band 4, Teil T, Berlin, 1938.

TABLE II

COMPARISON OF HAWAIIAN STATIONS WITH ISLAND STATIONS IN THE SOUTH PACIFIC AND OTHER OCEANS

Station	Latitude	Rainfall (inches)	Annual range of temp.	Seasonal lags (days)		Length of record (years)	Source of data
				Winter	Summer		
Noumea (New Caledonia)	22° 16′ S.	44	10.4	39	43	10	Reed
Waialua	21° 35′ N.	31	7.6	44	45	..	....
Avarua (Cook Is.)	21° 12′ S.	83	8.0	38	53	28	Schott
Koloa	21° 54′ N.	64	7.4	47	55	..	....
Alofi (Tonga Is.)	19° 2′ S.	85	6.9	34	48	10	Clayton
Suva (Fiji Is.)	18° 8′ S.	112	6.8	43	50	33	Reed
Hilo	19° 44′ N.	137	5.2	56	53	..	....
Papeete (Tahiti)	17° 32′ S.	56	4.1	35	60	15	Reed
Mauritius	20° 6′ S.	54	10.6	40	41	10	Clayton
Honokaa	20° 6′ N.	68	5.8	51	56	..	....
San Juan (Puerto Rico)	18° 29′ N.	61	5.6	53	50	26	Clayton
Christiansted (Virgin Islands)	17° 45′ N.	47	6.0	42	50	40	Clayton
Pahala	19° 13′ N.	43	5.3	59	65	..	....

esting results to California and to the Great Lakes region.[6] Leighly's device will not serve for Hawaiian temperatures, chiefly because changes near the extremes are so small as to make unreliable any mathematically-fitted curve.

A first approximation to an analysis of seasonal lag in Hawaii is presented in Table III. It shows the months of highest and lowest mean tem-

TABLE III

MONTHS OF HIGHEST AND LOWEST MEAN TEMPERATURES AT HAWAIIAN STATIONS (WHERE TWO MONTHS HAVE SAME MEAN TEMPERATURE, BOTH ARE ENTERED)

	All stations	Kauai	Oahu	Maui	Hawaii
Highest monthly mean					
July	0	0	0	0	0
August	35	7	9	2	9
September	20	1	2	5	13
October	1	0	0	1	0
Lowest monthly mean					
January	30	5	10	1	14
February	22	2	5	6	6
March	3	0	0	3	0

[6] John Leighly: The Effects of the Great Lakes on the Annual March of Temperature in Their Vicinity, abstract, these *Annals*, vol. 30, 1940, p. 64.

perature at the 43 stations here studied. It will be noted that no maximum occurs in July, first month after the summer solstice, while 30 minima fall in January, first month after the winter solstice. Summer lag equals or exceeds winter lag at every station, but later work will show that the difference is much less than the month suggested by Table III. That there is some tendency for late maxima to accompany late minima is shown by the figures for Maui. That this rule is not inflexible is brought out by the data for the island of Hawaii. One reason for inconsistency, when extreme months only are considered, lies in the frequent dryness and warmth of Februaries in the present century.[7] Table III suggests that seasons come later on Maui and Hawaii than on Kauai and Oahu. The explanation is simply that Maui and Hawaii have a greater proportion of their stations on rainy windward coasts.

Daily means provide another method of obtaining seasonal lag. Such means are available for Honolulu. The resulting sinuous curve has been smoothed in two ways. Marvin and Day[8] determined weekly means from the daily means, then fitted a curve to these fifty-two points. Palmer[9] computed seven-day running means from daily means for the period 1890 to 1930, inclusive. So flat is the Honolulu temperature curve that the two computations give extremes differing by nearly two weeks, the lags by Palmer's method being longer. This difference, and the labor of working with daily means, led the writer to seek a measure of seasonal lag independent of the very flat portions of the annual curve. After some experiment, the lags of the midpoints of the 120 warmest and 120 coolest days were adopted. Such lags are not necessarily commensurable with those obtained by other methods. Annual curves were plotted with large vertical scale (temperature). Vertical scales were adjusted to annual range, so that all curves had about the same amplitude. Intercepts of the 120-day periods fell on steep and straight portions in most cases (Fig. 5). To avoid subjectivity, the curves were not smoothed. This makes little difference in the portions used. Months were assumed to be of equal length. Probably the combined errors of plotting, scaling, lack of smoothing, and assumption of equal months never exceed two days. Similar curves were plotted for oceanic areas about the islands (Fig. 6).

[7] Whether dry Februaries are an intrinsic feature of the Hawaiian climate or merely a persistent abnormality cannot be decided, though nineteenth century records suggest the latter. See S. B. Jones: The Weather Element in the Hawaiian Climate, these *Annals*, vol. 29, 1939, footnote 24, p. 52.

[8] C. F. Marvin and P. C. Day: Normals of Daily Temperature for the United States, *Monthly Weather Review Supplement* 25, 1925, p. 38. The period of the Honolulu record is not stated.

[9] H. S. Palmer, University of Hawaii, personal communication.

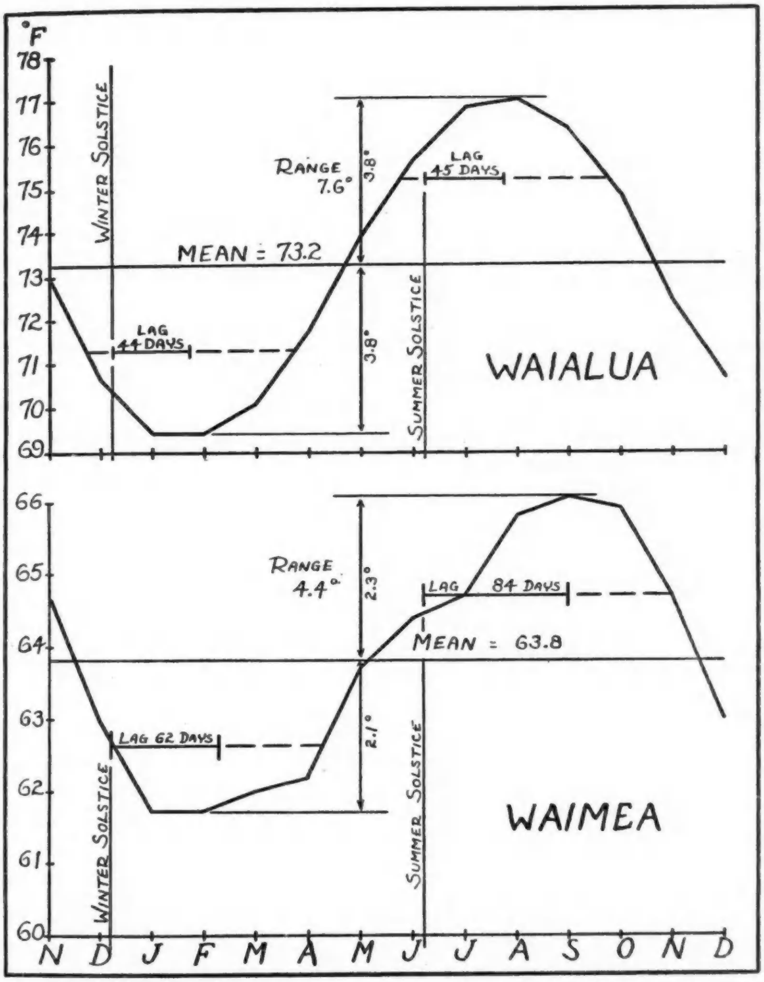


FIG. 5.—Annual temperature curves for Waialua, Oahu, and Waimea, Hawaii, showing method of determining seasonal lag.

A number of Hawaiian stations show seasonal lags about as long as those of the oceanic air surrounding the islands. These stations, in general, are those with low annual ranges on rainy, windward coasts of Maui and Hawaii (Fig. 7). Waimea, Hawaii, though eight miles from the sea,

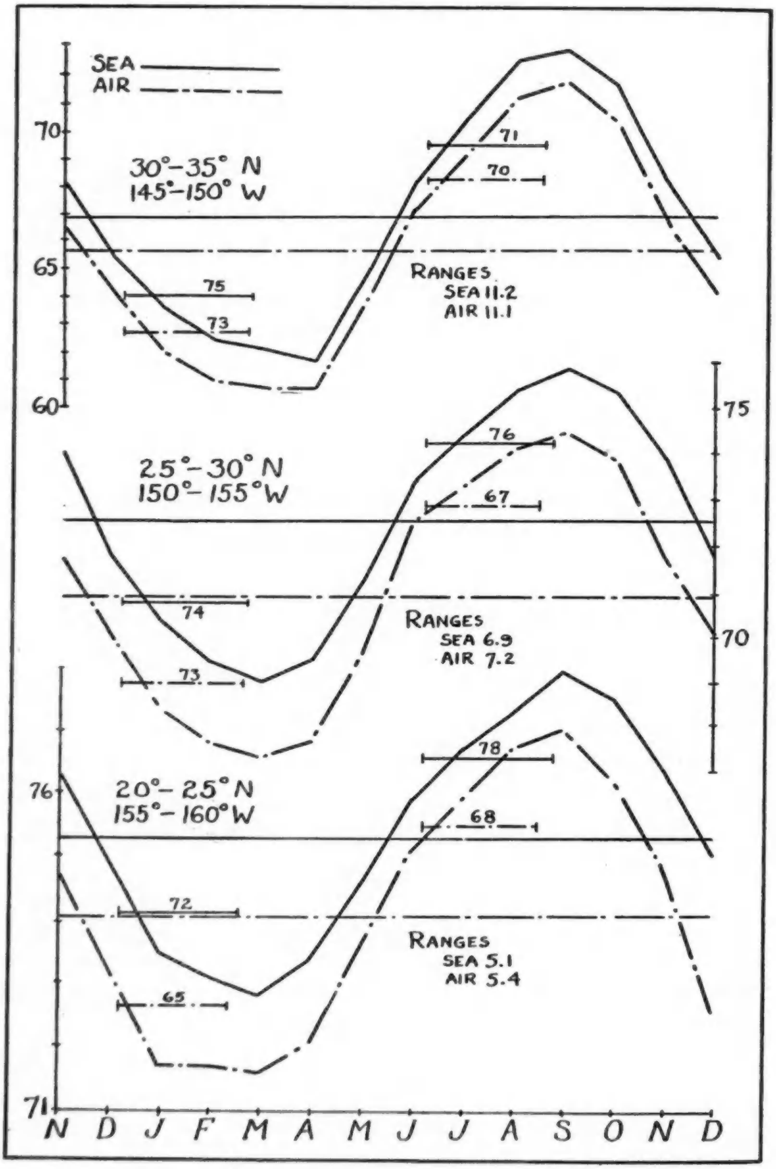

SEA
AIR
70
65
60
30°-35° N
145°-150° W
71
70
75
73
RANGES
SEA 11.2
AIR 11.1
75
70
25°-30° N
150°-155° W
76
67
74
73
RANGES
SEA 6.9
AIR 7.2
76
71
20°-25° N
155°-160° W
78
68
72
65
RANGES
SEA 5.1
AIR 5.4
N D J F M A M J J A S O N D

FIG. 6.—Annual temperature curves for the ocean and oceanic air for three five-degree quadrangles northeast of Hawaii.

shows a summer lag as long as that of the ocean water itself, possibly because turbulence and cloud in this mountain gap are most marked during the summer months of steadiest trades (Fig. 2). Kealakekua, on the leeward side of the same island, has lags both summer and winter greater than those of the ocean water. This station will be examined in more detail later. Kiolakaa, Hawaii, with moderate rain but well exposed to the wind, shows long lags.

Short lags are characteristic of dry stations with moderate wind, whether with windward or leeward exposure. The shortest lags (Waialua, Oahu) appear to be related to a sheltered site. Waialua, though near a shore and not extremely dry or sunny, is so situated that winds from any direction between northeast and west, through south, must pass over land at least 850 feet high (Fig. 1). Some stagnation of climatologic air is thus probable.

Between Waimea, Hawaii, and Waialua, Oahu—the long-record stations with longest and shortest lags—winter lags differ by 18 days, summer lags by 39. On the island of Maui, Haiku and Kaanapali, in an air line 24 miles apart, show lags differing by about two weeks.

Seemingly minor factors can produce lag differences of as much as a week. Olaa, Hawaii, on a level site four miles inland, shows lags a week shorter than those of Ookala, almost equally rainy, which lies on a slope above a sea cliff. There is undoubtedly more movement of the climatologic air at Ookala.

The difference between the summer and winter lag at each station can be read from Figure 7. Not too much reliance can be placed on these differences, for they are smaller than possible errors in many cases. It appears to be true that sheltered stations, like Maunawili Ranch and Waialua, Oahu, show less difference than more exposed places, like Tantalus, Oahu, and Waimea, Hawaii. In a well sheltered site, the climatologic air may not be greatly affected by seasonal shifts of wind. Exposed stations may be very sensitive to such changes.

Histograms of lags, grouped in five-day classes, are given in Figure 8. The winter histogram resembles that of summer, transposed five days. The mode of winter lags is a class lower than summer, not a month lower as Table III suggested.

Seasonal lags appear to be shorter in general at southern hemisphere island stations (Table II), but the differences may be explicable by site factors.

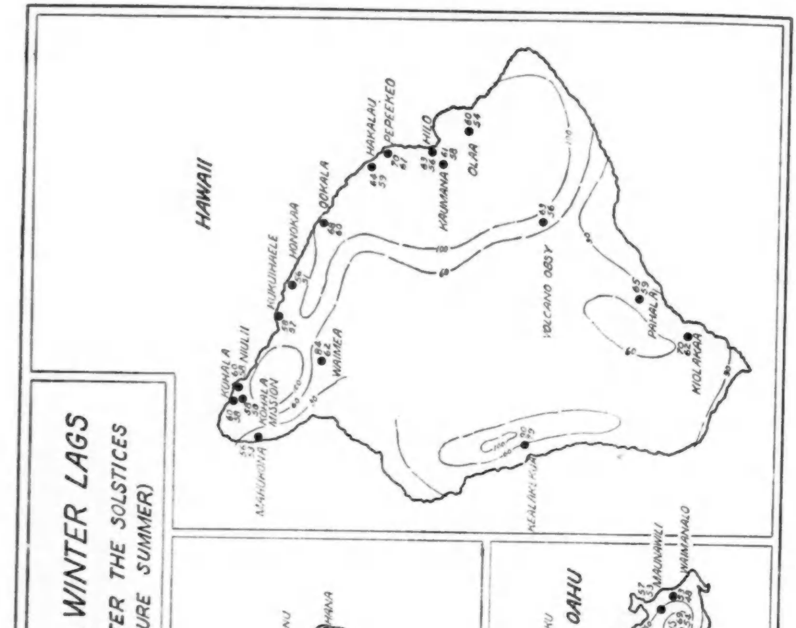

SUMMER & WINTER LAGS
IN DAYS AFTER THE SOLSTICES
(UPPER FIGURE SUMMER)
HAWAII
MAUI
OAHU
KAUAI
NIIHAU
MOLOKAI
LANAI
KAHOOLAWE
HILO
KOHALA
WAIMEA
HONOKAA
OOKALA
VOLCANO OBSY
SCHOFIELD
HONOLULU
KILAUEA
LIHUE
KOLOA
MANA
HANA
WAILUKU
HAIKU

FIG. 7.—Summer lags (upper) and winter lags, in days after the solstices.

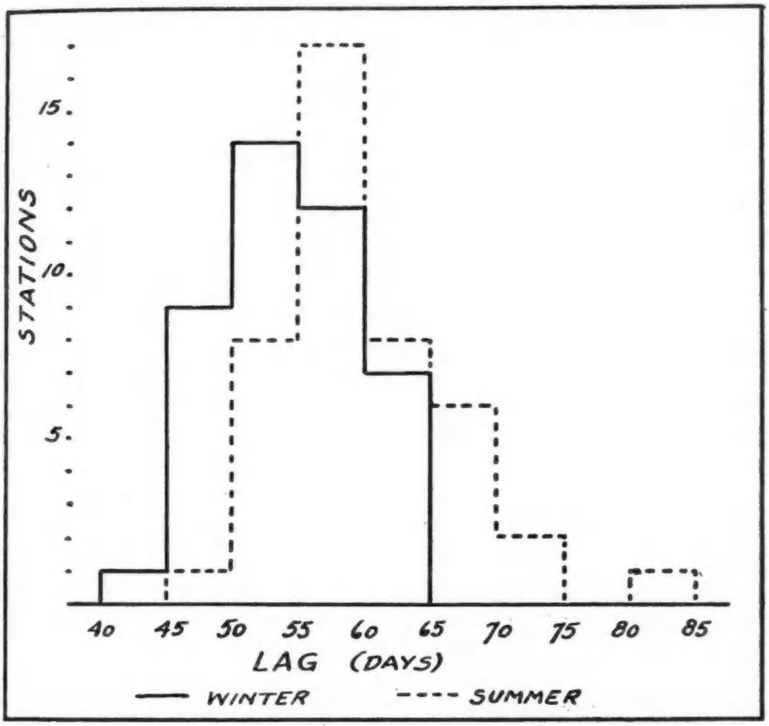


FIG. 8.—Histograms of summer and winter lags.

THE SHAPE OF THE ANNUAL TEMPERATURE CURVE

Experimental curves for determination of lag showed that the annual march of temperature at some stations in the islands approximates a sine wave while at others there are indentations and truncations (Fig. 5). To facilitate comparison, the final curves were plotted with vertical scales adjusted for annual range, giving waves of nearly the same amplitudes (Fig. 9). The order of stations in Figure 9 follows propinquity as far as possible.

The closest approximations to a sine wave are found at dry or sheltered stations. Deviations, commonest at wet or windy stations (Figs. 9 and 10), are (a) winter truncation or indentation, usually with warm Februaries,

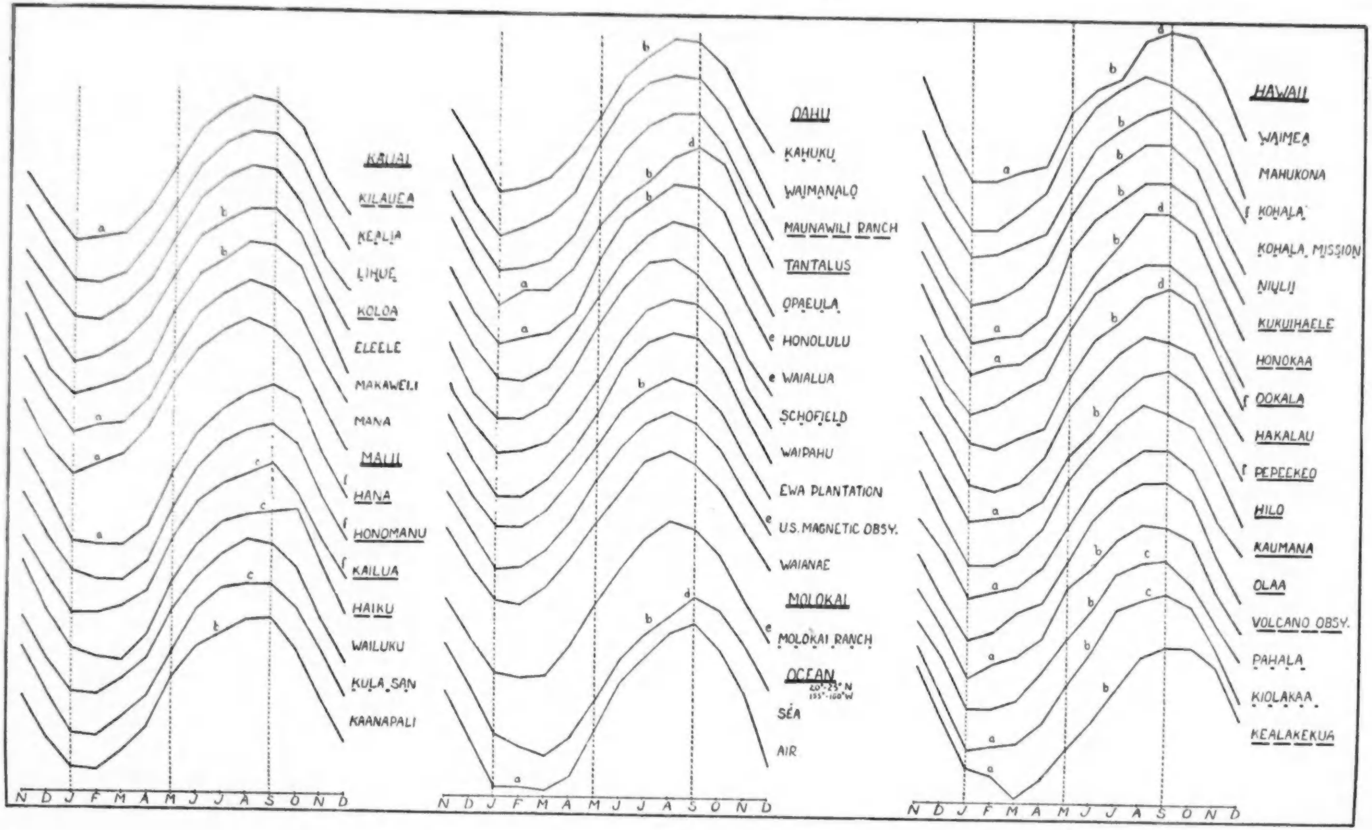

KAUAI
KILAUEA
KEALIA
LIHUE
KOLOA
ELEELE
MAKAWELI
MANA
MAUI
HANA
HONOMANU
KAILUA
HAIKU
WAILUKU
KULA SAN
KAANAPALI
OAHU
KAHUKU
WAIMANALO
MAUNAWILI RANCH
TANTALUS
OPAEULA
HONOLULU
WAIALUA
SCHOFIELD
WAIPAHU
EWA PLANTATION
US. MAGNETIC OBSY.
WAIANAE
MOLOKAI
MOLOKAI RANCH
OCEAN
SEA
AIR
HAWAII
WAIMEA
MAHUKONA
KOHALA
KOHALA MISSION
NIULII
KUKUIHAELE
HONOKAA
OOKALA
HAKALAU
PEPEEKEO
HILO
KAUMANA
OLAA
VOLCANO OBSY.
PAHALA
KIOLAKAA
KEALAKEKUA
N D J F M A M J J A S O N D

FIG. 9.—Annual temperature curves for all Hawaiian stations with records of twenty or more years (through 1935). Vertical scales (temperature) adjusted to give similar amplitudes.

Examples of certain characteristic features are indicated thus: (a) Winter truncation or indentation; (b) Early summer indentation or retardation of rise; (c) Mid-summer truncation; (d) Narrow summer peak; (e) Curve approximately sinusoidal; (f) Curve resembling that for oceanic air.

Underlinings signify the following: Double, name of island; Single solid, rainfall 100 inches or more; Broken, rainfall 60–100 inches; Dotted, rainfall 30–60 inches; None, rainfall under 30 inches.

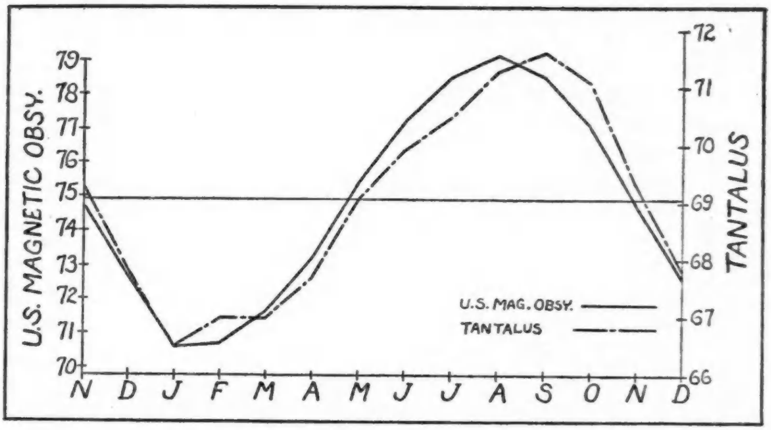


FIG. 10.—Temperature curves for Tantalus and U. S. Magnetic Observatory, Oahu, compared.

(b) early summer indentation or retardation of rise, (c) mid-summer truncation, (d) narrow summer peak, often following and probably due to early summer indentation.

The irregularities are more easily explained than are the basic curves. In the present century, February has often been a dry month (see footnote 7). Especially at a rainy station, a dry winter month will tend to be warm. Dry Februaries probably account for most of the winter indentations and truncations and the large proportion of January annual minima (Table III). By omitting February it is often possible to draw a sinusoid through winter monthly means.

Coolness of early summer, relative to late summer and fall, is a feature of ocean water temperatures near the islands (Fig. 6). Wave turbulence in the trade wind months may explain this retarded rise. The same feature is to be observed in the curves for oceanic air, and for most windward and many leeward stations. At many stations there is a fairly rapid rise of

temperature in May and June, with a flattening or an indentation in July (*e.g.*, Waimea, Fig. 5). Several factors may be involved. The trade winds are somewhat less steady in May and June than in mid-summer, with more calms (Fig. 2). June is the least rainy month at many stations, suggesting atmospheric stability. Thus the upward transfer of heat by convection may be less active, permitting rapid increase of climatologic air temperatures.

Summer truncations at Haiku, Maui, and, less perfectly, at Kiolakaa and Pahala, Hawaii, are probably wind effects. Truncation at Kula Sanatorium, Maui, a sheltered station, undoubtedly comes from summer convectional clouds on the lee slopes of Haleakala, 10,000 foot mountain mass of East Maui (Fig. 1).

Explanations for the basic curves are less convincing. Theoretical values of insolation for various latitudes have been computed by Angot and Milankovitch.[10] One cannot expect, however, identity of shape between the insolation wave and the temperature wave which follows it after a lag of weeks or months. In middle latitudes, theoretical insolation curves approximate sine waves. In ocean water, as discussed by Leighly and in an earlier section of this paper, convection should broaden the winter trough and retard the minimum. Such is the case in the rectangle 30–35 degrees north, 145–150 degrees west (Fig. 6). The summer peak by this theory seemingly should be nearer the solstice. It is possible, however, that trade wind retardation of early summer rise is effective as far north as latitudes 30–35. The theoretical insolation curve for latitude 20 north shows a deep, sharp winter trough and broad summer plateau (Fig. 11). Ocean temperatures for 20–25 degrees north, 155–160 degrees west—the rectangle northeast of the Hawaiian Islands—show little relationship to theoretical insolation. The broad, retarded winter may be explained, as before, by vertical circulation. The non-appearance of a summer plateau might be an inheritance from the middle latitudes, through which the water may have passed in the main clockwise circulation of the North Pacific. However, there is little or no persistence in annual range (Fig. 6), so it is unlikely there is much persistence in other temperature characteristics. Other explanations may be offered: The spring slope of the theoretical plateau may be eroded by the widening of the winter valley and the onset of steady trades. A summer minimum of cloudiness might permit a doming of this plateau. Such a minimum is reported for several Hawaiian stations but is not indicated for the neighboring seas in the "Atlas of Climatic Charts of the Oceans" (Charts 67–70).

[10] D. Brunt: *Physical and Dynamical Meteorology*, Cambridge, 1939, p. 112.
M. Milankovitch: Mathematische Klimalehre, *Handbuch der Klimatologie*, Band I, Teil A, Berlin, 1930, pp. 14–15.

Rainy or cloudy windward stations, like Hana and Honomanu, Maui (Fig. 9), show curves almost identical with those of the ocean or ocean air. Drier stations, with shorter lags and greater annual ranges, have curves more nearly sinusoidal. Since the climatologic air of leeward stations was oceanic air not many hours previously, it has undergone rapid modification. The modifications lead to (a) sharpening the winter trough with decrease of lag, (b) filling the early summer slope, and (c) rounding and advancing the summer peak. Obviously these modifications are the result of the more intense lee slope insolation, with less cloud interference, and are in the direction of the insolation curve.

MEASUREMENTS OF SUNSHINE AND CLOUD IN HAWAII

Sunshine and cloud measurements of four kinds have been made in the Hawaiian Islands. They are (a) estimates of cloudiness made at Weather Bureau co-operative stations, (b) instrumental records of duration of sunshine, expressed as percent of possible duration, (c) sun temperature records with black-bulb thermographs, and (d) solar radiation measurements with pyrheliometers.

Monthly mean cloud estimates are available for ten stations, mostly on

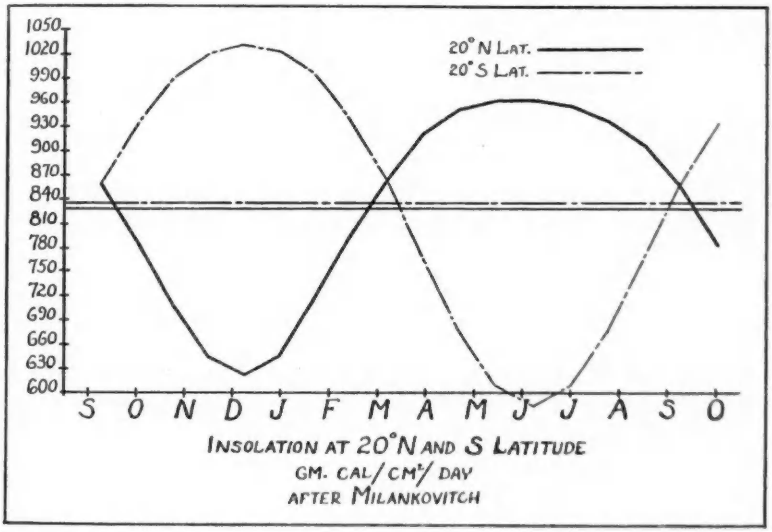


FIG. 11.—Theoretical insolation curves for 20 degrees north and 20 degrees south latitude.

Oahu. Unfortunately, little reliance can be placed on these data. They are highly subjective and at most stations are based on sky conditions only at a few times of day. However, the ten stations give the general picture of greatest cloudiness in winter. May opens the season of low cloudiness at several of the stations.

Long instrumental records of duration of sunshine are available for Honolulu and Honokaa, the latter a rainy station on the windward Hawaii coast (Fig. 1). Honolulu shows little annual variation, the percent of possible sunshine ranging from 58 in March to 69 in August. The curve shows a secondary peak in February and an early summer indentation. Neither feature is reflected in the Honolulu temperature curve, though they appear at the rainy station, Tantalus, a few miles inland. At Honokaa the percent of possible sunshine ranges from 46 in April to 65 in June. The temperature curve shows an April indentation and a rather warm June. These features are found at some other windward stations, such as Kohala and Ookala. Kukuihaele, only eight miles north of Honokaa, is cool in June (Fig. 9) and has long lags (Fig. 7). Kukuihaele lies near the entrance to the Waimea gap. Waimea likewise has a cool early summer and long lags.

Sun temperatures have been measured with black-bulb thermographs in experimental work with sugar cane and pineapples and are routine observations on some plantations. Pyrheliometers are operated at two sugar experiment stations on Oahu. The period of these observations is not yet sufficient to establish monthly means. Results of shade and black-bulb thermograph observations over a period of twenty-one months have been published by Clements.[11]

ANNUAL CURVES OF MAXIMUM AND MINIMUM TEMPERATURES

For most Hawaiian stations, annual curves of mean monthly maxima and minima are little different in shape from curves of monthly means.[12] At most windward stations the lag of the maxima is longer than the lag of the minima. At most leeward stations the reverse is true. That is, daily range of temperature is low in summer at windward stations, increasing after the months of steady trades.

Stations with irregular temperature curves may have quite smooth

[11] H. F. Clements: Integration of Climatic and Physiologic Factors with Reference to the Production of Sugar Cane; *The Hawaiian Planters' Record*, vol. 44, 1940, pp. 201-233.

[12] In U. S. Weather Bureau practice, the daily mean is the average of maximum and minimum. Therefore, the mean curve will appear to be a compromise between the curves of mean maxima and minima.

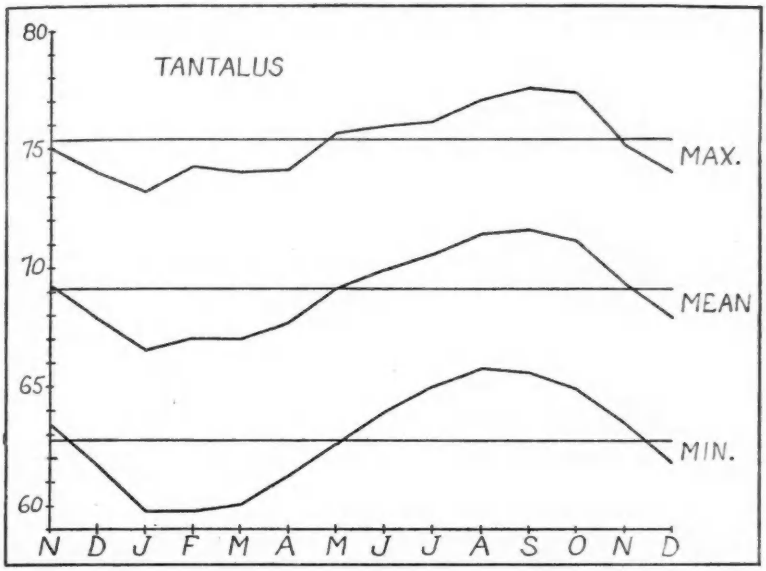


FIG. 12.—Maximum, mean, and minimum temperature curves for Tantalus, Oahu.

curves of minima, the peculiarities appearing in the maxima. (The reverse may be possible, but no clear instance has been discovered in the course of the present work.) At Tantalus (Fig. 12), the temperature rise of dry February is strong in the maxima, but the greater daily range of dry weather eliminates it from the minima. A residual peak appears in the mean curve. The early summer coolness makes a plateau in the maxima curve but is not visible in the minima, perhaps because surface winds are weak by night. Kealakekua, in the coffee belt of leeward Hawaii, is characterized by absence of trade winds at all seasons, afternoon sea breezes strongest in summer, land winds at night, a summer and afternoon-evening cloud and rain maximum. The Kealakekua temperature record, unfortunately only ten years long, gives a smooth curve with small annual range and enormous lags (Fig. 13). The curve of minima is regular and normal, with low point in February and high in August. The great lags, reflected in the mean, are to be found in the maxima. The coolests days come in April, for winter days are more apt to be clear. There is little rise before July. July days normally are cooler than January days. The warmest days come in November, after the cloudiest season and only a month before the winter

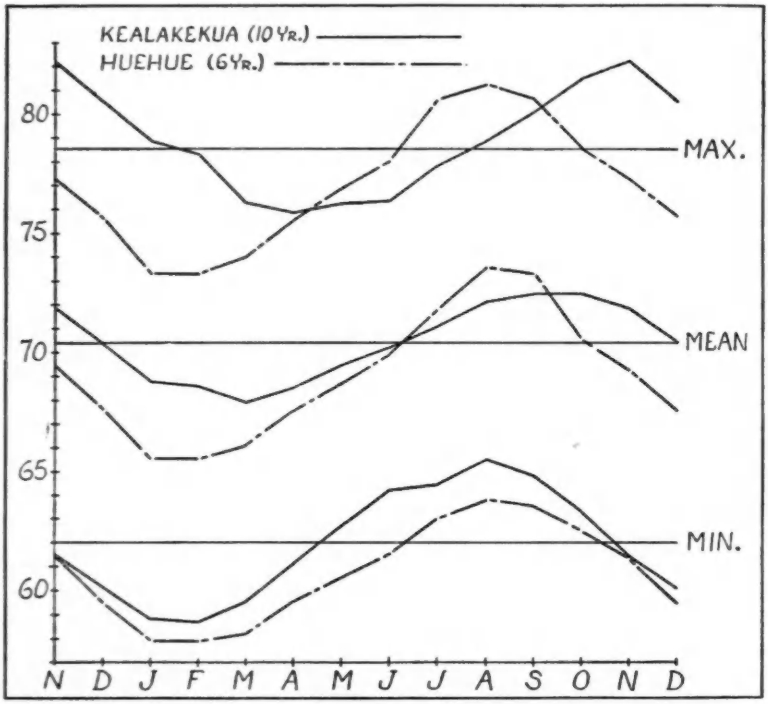


FIG. 13.—Maximum, mean, and minimum temperature curves for Kealakekua and Huehue, Hawaii.

solstice. Comparison with a short record from Huehue, north of the cloud belt, emphasizes these features. Huehue shows normal leeward curves, with August peak and January-February trough in all three elements.

Temperature curves for the stations of Table II are given in Figure 14. Only Alofi (a short record) shows winter indentation or pronounced early summer retardation of rise. Noumea seems to have a truncated summer peak. The West Indian stations show relatively warm early summers.

DAILY RANGE OF TEMPERATURE

It is well known that the daily range of temperature is large in dry climates and at high altitudes, low in cloudy places near the sea. The relationship to cloud and sun is obvious in Hawaii (Fig. 15). The altitude effect is masked by cloudiness up to the highest long-record station, Vol-

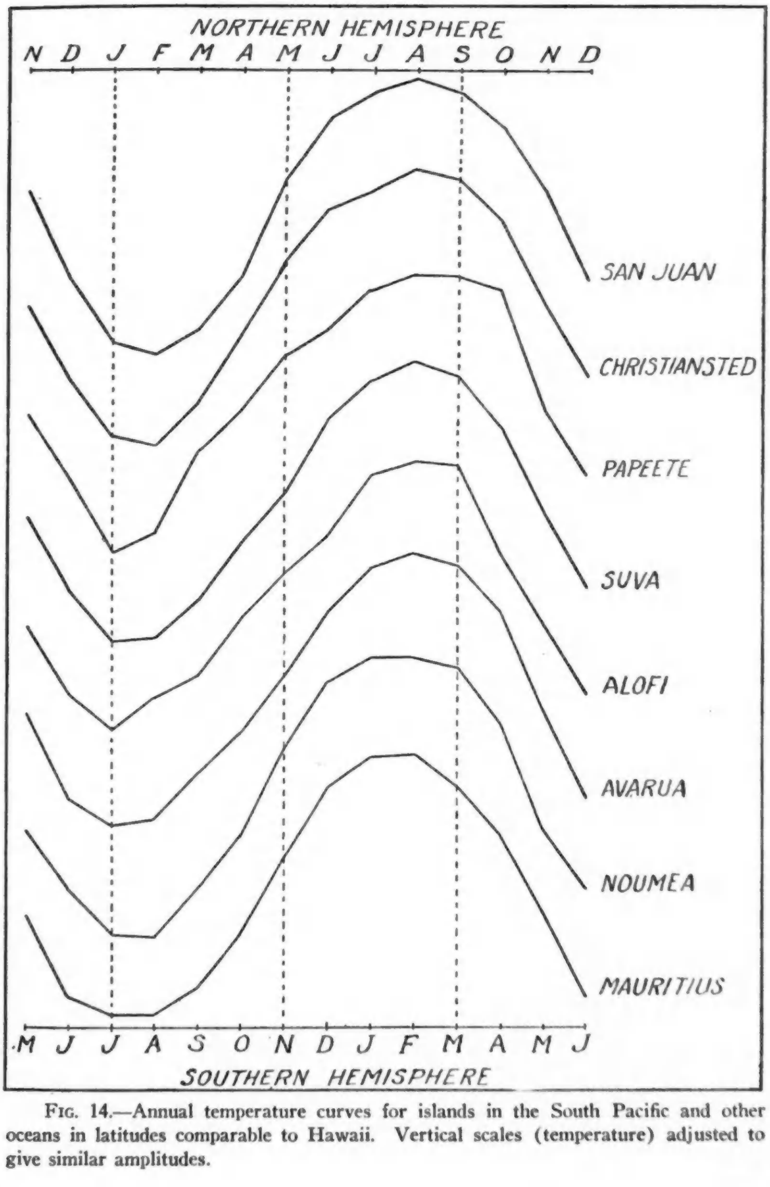


FIG. 14.—Annual temperature curves for islands in the South Pacific and other oceans in latitudes comparable to Hawaii. Vertical scales (temperature) adjusted to give similar amplitudes.

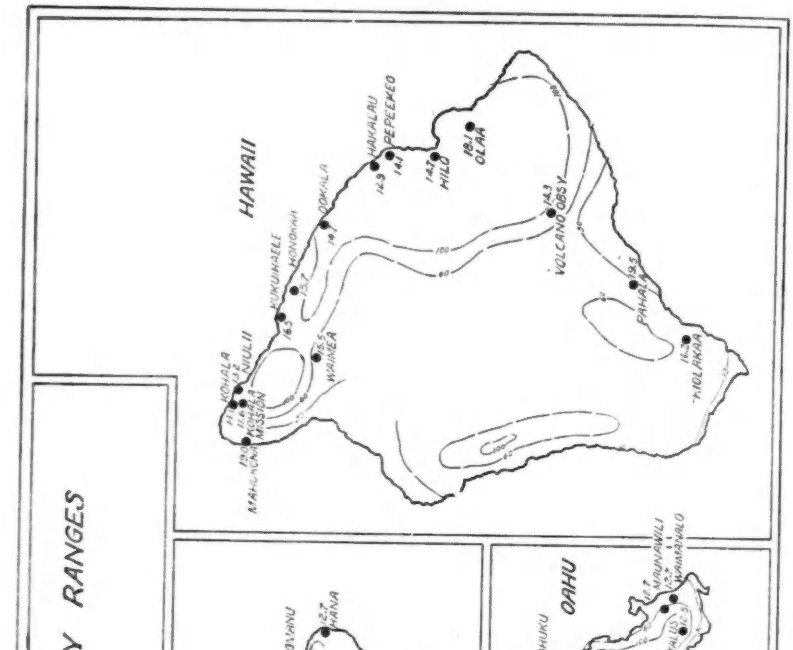

DAILY RANGES
HAWAII
MAUI
OAHU
KAUAI
NIIHAU
MOLOKAI
LANAI
KAHOOLAWE
HILO
OLAA
VOLCANO OBSY
PAHALA
WAIMEA
HANA
KAHUKU
SCHOFIELD
LIHUE
KOLOA
ELEELE
MANA
KILAUEA

FIG. 15.—Daily range of temperature (annual means).

cano Observatory at 3979 feet. A twelve-day record from Lake Waiau, on Mauna Kea, at 13,010 feet, far above the cloud belt, indicates a daily range of about 26 degrees.[13]

Daily range is an item that must be used with caution, for the major controls may be offset by differences in site or the exposure of the thermometers. For example, the Honolulu Weather Bureau station, with thermometers 87 feet above the ground, records a mean daily range of 9.5 degrees, which is perhaps two-thirds of what might be expected near ground-level.

On the whole, Figure 15 shows reasonable consistency. Daily ranges on windward Hawaii seem rather large in comparison with other islands, in view of the heavy rainfall of that coast. Rainy Olaa reports daily ranges of leeward magnitude. Olaa is four miles from the sea, on a fairly level plain, and receives nocturnal air drainage from the mountains to the west.[14] The relatively high daily ranges of other windward Hawaii stations may likewise be influenced by air drainage from the very high mountains of that island.

The annual variation of daily range is clearly related to exposure. Windward stations have least daily range in summer, when trade winds are steadiest. Leeward stations have least daily range in winter, when variable winds permit sea effects on lee coast temperatures. Figure 16 shows that few stations contradict this rule (which holds most strikingly for Kauai), though many of the curves are so flat or irregular as to be indeterminate.

Dry February shows up consistently in the daily range curves, especially at rainy stations. October, often a month of light and variable winds, shows high range in many cases. In Figure 17, "non-rainy days" (less than 0.01 inch precipitation) have been plotted. Close similarity in shape to daily range curves is seen, but there is no quantitative correlation. That cloud or sea air rather than rain may be the causal factor is indicated by curves for stations near the windward-leeward borderline, such as Eleele (Kauai), Waimanalo (Oahu), and Wailuku (Maui). At these stations, daily range bows down in summer, windward fashion, but non-rainy days bow upward, leeward fashion. This may mean that trade-wind cloud or air reduces the daily range but brings insufficient precipitation to give a "rainy day."

In Figure 18, temperature curves for Mana and Lihue, leeward and

[13] C. T. Raine: Meteorological Reports of the Mauna Kea Expedition, 1935, Part II, *Bulletin of the American Meteorological Society*, vol. 20, 1939, p. 101.

[14] Mr. Paul Sakamaki, Olaa Sugar Company, personal communication.

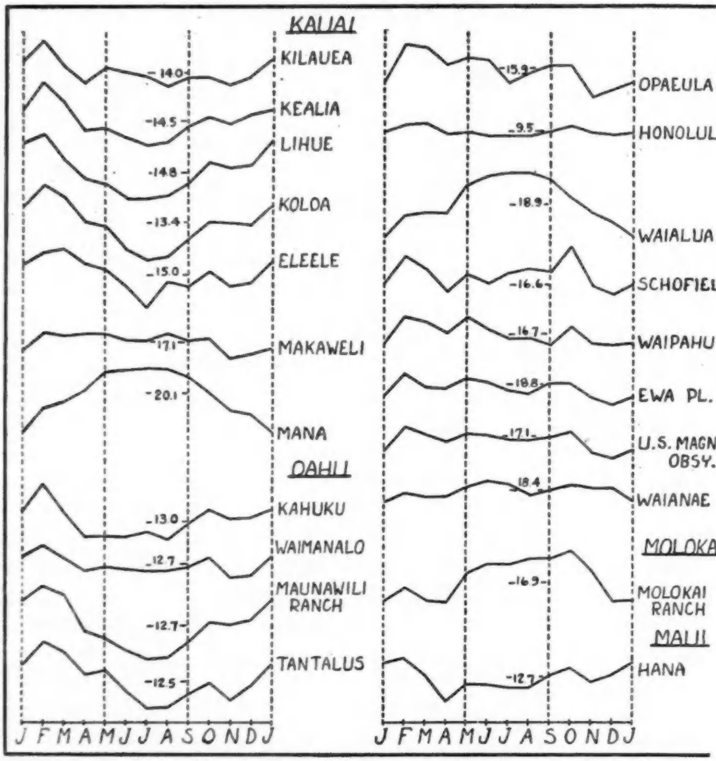


FIG. 16.—Daily range of temperature (monthly means). Numerals give annual means.

windward stations on Kauai, have been superimposed. Temperatures for Lihue have been increased slightly to compensate for altitude and to bring annual means into coincidence. The two stations have much the same daily range in winter, when variable winds partly destroy the distinction between windward and leeward. In summer, Mana has warmer days and cooler nights. In line with the rule stated in an earlier section, windward Lihue has its highest maximum after its highest minimum, while the contrary is true for Mana.

SUMMARY

It has been shown that land masses as small as the Hawaiian Islands have important effects on the annual march of temperature. These effects are amplified by the mountainous character of the islands and the steadiness

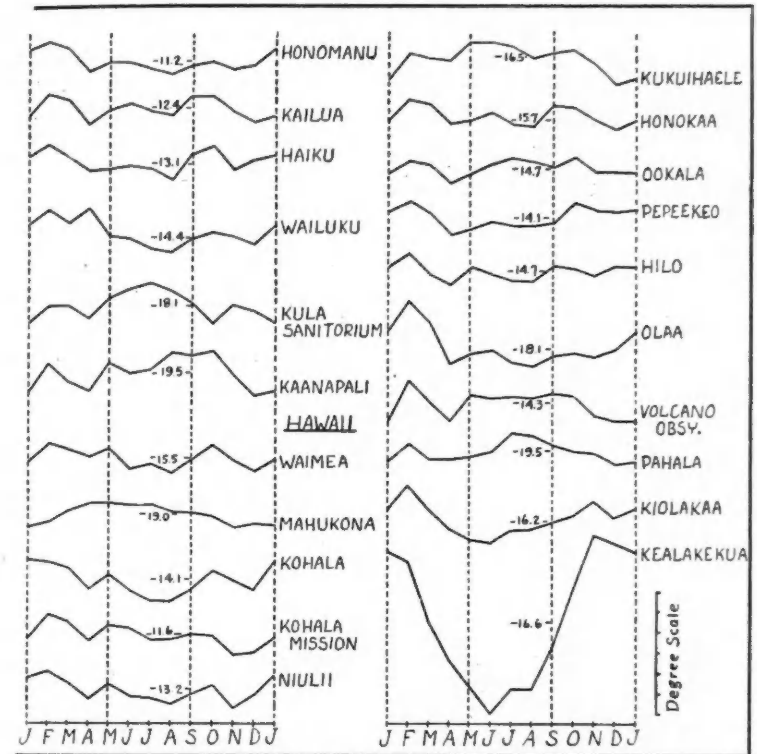
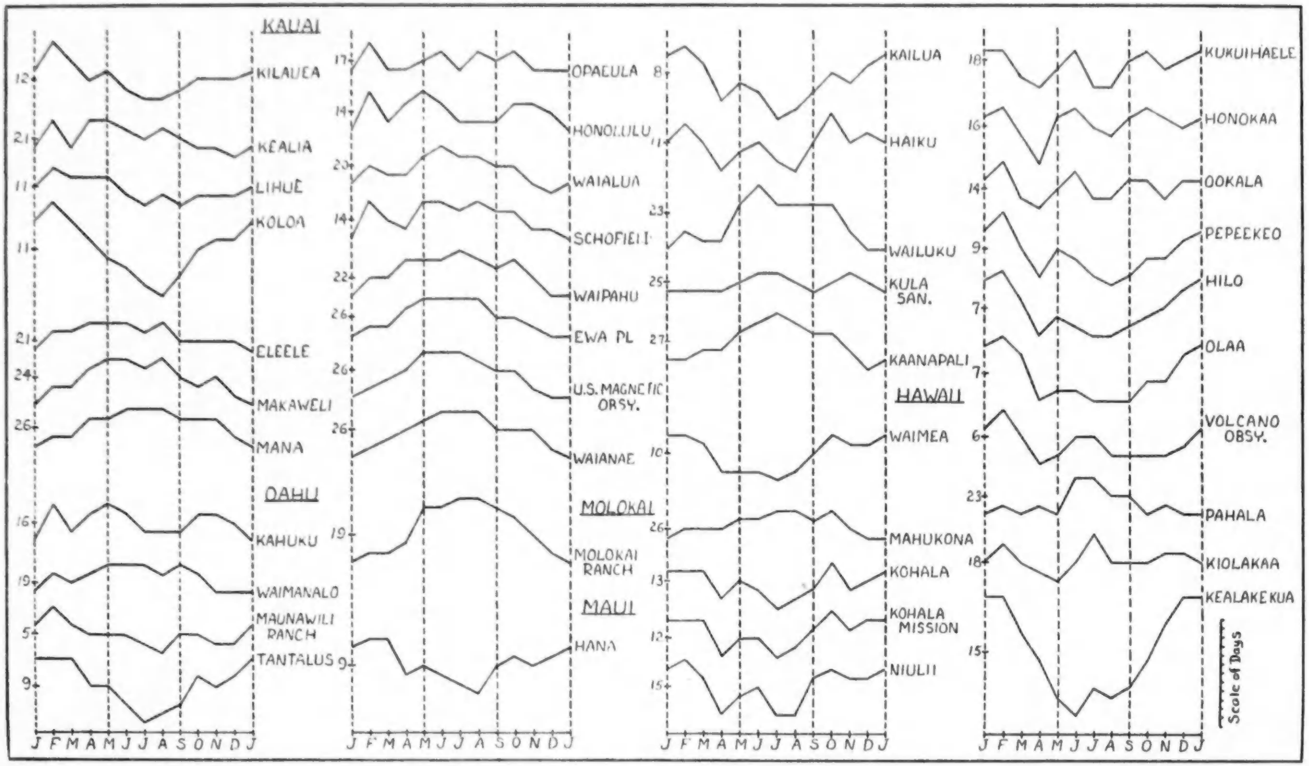


FIG. 16.—Daily range of temperature (monthly means). Numerals give annual means.

of the winds. Temperature regimes like those of the ocean are most common on windward sides, but differences in the circulation of the climatologic air, due to landforms, and shielding or cooling by cloud or rain complicate the intra-island patterns of seasonal lag and annual range. Inland stations may be more marine in temperature than some near windward coasts. The extent to which the oceanic regime is modified on the islands depends upon factors which are to a considerable degree interchangeable. A sunny but windy station may yield somewhat the same temperature curve as a calm but cloudy one. The limitations of an empirical study make it difficult to go beyond an enumeration of possible explanations in such cases. It has been shown that low annual ranges, in Hawaii, result from cool summers rather than warm winters, but that abrupt truncation of the summer peak is uncommon. A broad winter trough and a delayed spring rise—both at



KAUAI
KILAUEA
KEALIA
LIHUE
KOLOA
ELEELE
MAKAWELI
MANA
OAHU
KAHUKU
WAIMANALO
MAUNAWILI RANCH
TANTALUS
OPAEULA
HONOLULU
WAIALUA
SCHOFIELD
WAIPAHU
EWA PL
U.S. MAGNETIC OBSY.
WAIANAE
MOLOKAI
MOLOKAI RANCH
MAUI
HANA
KAILUA
HAIKU
WAILUKU
KULA SAN.
KAANAPALI
HAWAII
WAIMEA
MAHUKONA
KOHALA
KOHALA MISSION
NIULII
KUKUIHAELE
HONOKAA
OOKALA
PEPEEKEO
HILO
OLAA
VOLCANO OBSY.
PAHALA
KIOLAKAA
KEALAKEKUA
Scale of Days
J F M A M J J A S O N D J

FIG. 17.—Days without measurable precipitation (less than 0.01 inch), by months. Numerals indicate magnitude but are not means.

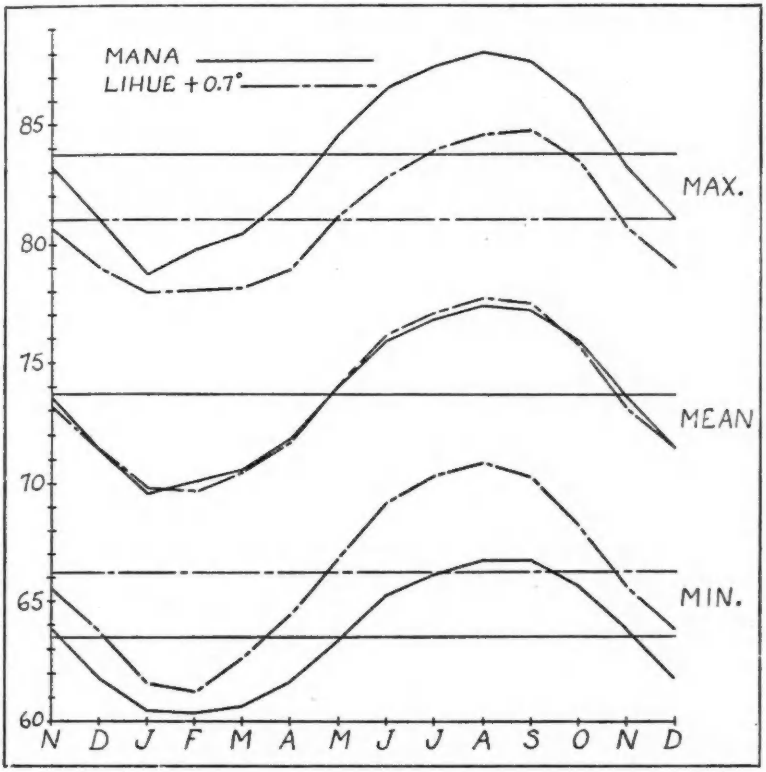


FIG. 18.—Maximum, mean, and minimum temperature curves for Mana and Lihue, Kauai. Lihue temperatures adjusted to Mana mean.

variance with the theoretical insolation for the latitude—are oceanic characteristics found at many island stations. Storage of heat in the sea water is adequate to explain these features. Variations in daily range with place and season are related to the factors that control annual range and seasonal lag.

University of Hawaii.
February, 1941.

Titles and Abstracts of Papers, New York City, December, 1941

GRIFFITH TAYLOR.

Environment, Village and City.

(Presidential Address. Published in full in this issue.)

ALFORD ARCHER. (Introduced by Guy-Harold Smith.)

Rural-Urban Population Ratios.

Maps which depict the distribution of population are of the utmost importance to the economic geographer and particularly as he deals in the field of land use. Such maps are numerous and utilize a variety of methods. Dots, squares and spheres have been used to represent absolute population numbers; isarithms and shadings have been used to represent population ratios such as the density of people per square mile and the proportion of the urban and rural numbers in the total population. This paper treats of a new method in the representation of urban-rural population ratios using the State of Ohio as a sample area.

The statistical basis for computation is minor civil divisions. For each political subdivision an index of rurality is obtained by dividing urban population by rural population. The resulting quotient is multiplied by 100 in order to have the indexes on the basis of per cents. These indexes may range from zero to infinity as, for instance, if one minor civil division had no urban population, and another no rural population. Groups of indexes have been chosen as representing certain classes of geographic and economic homogeneity and these arranged by specific class intervals. For example, indexes from zero to and including 5 are ranked 1, indexes from 133 to and including 165 are ranked 9. The groups on either side of 100 are arranged so as to be comparable in the degree of "ruralness" or the opposite degree of "urbanness." The ranking of each minor civil division according to its class interval is then plotted upon the map and isopleths are drawn.

It is believed that this method, which allows for the representation of fine gradations in the urban-rural population ratios from area to area or the changes occurring in any given area over a period of time, is the most adaptable yet devised. The technique is tedious but the end product is simplicity itself. It is difficult to visualize 5,000 people in relation to 50,000 people but "ten times" as many is readily understandable. Such a map of urban-

rural ratios is a significant aid in the interpretation of population characteristics.

Rollin S. Atwood. (Introduced by Preston E. James.)

An Area Analysis of Alachua County, Florida.

A. Current Problems
   1. Agriculture
      a. Insecurity as regards quantity and quality of transient labor. Time of harvesting plays a large part in determining price.
      b. Unsatisfactory marketing facilities in the county.
      c. Poor quality pastures for livestock.
   2. Wood Industries
      a. Forest fires and intentional burning of grazing areas.
      b. Lack of coordination with agriculture.
      c. Poor quality of locally processed naval stores.
   3. Social Welfare
      a. Large percentage of rural houses substandard and unsanitary.
      b. High malaria rate, especially in karst topography section.

B. Recommendations
   1. Agriculture
      a. It may not be too fantastic to suggest that some type of transient labor union or organization would not only benefit the transient but would decrease the hazards, including cut-throat competition, faced by the farmer. Through cooperation, provided adequate high grade transient labor was guaranteed, sanitary dormitories and other facilities could be provided for transient use in the trucking regions.
      b. Assistance to farmers who wish to arrange for two-family farms.
      c. Provide local market facilities for truck and specialized crops.
   2. Wood Industries
      a. 100% coverage for fire control.
      b. Adjusted taxation or other encouragement to increase reforestation.
      c. Local centralized processing plant for naval stores.
   3. Social Welfare
      a. A county health unit.
      b. County or state-wide malaria control program.

c. Educational campaign for improved nutrition.
d. Better facilities for Negro education.
e. Improvement of rural housing and sanitation.

WALLACE W. ATWOOD AND WALLACE W. ATWOOD, JR.
The Front Ranges of the Canadian Rockies.

In pursuing our studies of physiographic evolution in the Rocky Mountain province we find, in the northern portion of the United States, that the mountain area contains abundant evidence of the sub-summit erosion surface which we have called the Rocky Mountain Peneplain. Farther north that surface, if ever present, has been modified by ice that moved southward from the Cordilleran center of accumulation. South of the area affected by continental glaciation extensive ice-front lakes were present for some time, and the shorelines of those lakes are conspicuous topographic features at many places.

In the areas visited the records of late Tertiary orographic movements on a gigantic scale are widespread and most impressive. In the front range of the Canadian Rockies the uplift has been on a very large scale and may be continuing during the present physiographic cycle. Mountain torrents and Alpine glaciers have dissected this huge, uplifted mountain mass and produced a magnificent scenic belt, several hundred miles in length and about 100 miles in width. Most of this area is now included in a chain of National Parks. In this portion of the Rocky Mountains the relationship of structure to the evolution of physiographic forms is beautifully illustrated at many places. Here is a land where we have found no evidence of Tertiary peneplanation.

WALLACE W. ATWOOD, JR.
Ice-Cap Erosion in High Mountain Regions.

Physiographers have frequently referred to mature slopes in high mountain regions as remnants of former peneplains. Some of these interpretations are unquestionably correct, but others are believed to be in error. For example, Willis T. Lee and others identified the smooth, sloping surface of Flattop Mountain in Rocky Mountain National Park as a remnant of an early Tertiary peneplain. Recent observations indicate that this may not be the case but instead that ice-cap erosion is responsible for the softened topography. In 1910 F. E. Wright reported extensive ice-cap erosion in the mountains of Iceland, but little attention has been given to the problem since that time.

Those who are familiar with the present distribution of glacial ice in the Canadian Rockies will recall that several fairly extensive ice fields or ice

caps still exist in that area. The Columbia ice field, northwest of Mount Athabaska, is probably the best known, since it is located near the Banff-Jasper highway, one of the few routes of travel through the region. This ice cap is situated in a rugged mountain region, filling several valleys and capping hundreds of square miles of the mountain area. At many places an ice wall, 400 to 500 ft. thick, appears on the summits of the mountains. Where the contact between the ice and bed-rock is visible, the effect of glacial planation is very evident. Joint plains, as well as other structural features, are being truncated by ice-scour. Within short distances of the present ice field mature mountain summits are common. These are the recently uncovered surfaces where ice erosion has softened the summit contours.

The great similarity between the ice-scoured surfaces in the Canadian Rockies and the softened crestline peaks in the Rocky Mountains of the United States is at once apparent. On the strength of this similarity and evidence to be reported in this paper, the smoothed summits of the Snowy Mountains in the Medicine Bow Range of Wyoming and the mature slopes on the mountains of the Front Range of Colorado are tentatively identified as the product of glacier scour.

Several of the mature surfaces in the White Mountains of New England and also in the Sierra Nevada of California have been recognized by some as the work of ice, while others are just as certain that they were produced by stream action. These divergent interpretations are unfortunate and indicate a lack of familiarity with the characteristics of stream- and ice-sculptured landscapes.

Differentiation is not easy since definite criteria for identification have not been established. The purpose of this paper is to call attention to this problem, which will confront all physiographers working in high mountain areas where glaciation has occurred, and to give a few specific examples of so-called "peneplain remnants" which in the opinion of the author are due to ice-cap erosion.

THOMAS F. BARTON. (Introduced by J. R. Whitaker.)
The Sudbury Area.

The Sudbury Area of Ontario is one of large scale mining and smelting, pioneer farming, and abandoned lumber camps, the whole superimposed upon an ice-scoured plain and set in a matrix of cut-over forest land. Located astride the Canadian Pacific railroad where it crosses the southern part of the Laurentian Highlands, this area produces most of the world's nickel and contains one of the agricultural "pocket" settlements of the Canadian Shield. Development today is associated primarily with the

presence of commercial ore bodies and secondarily with agriculture. The latter is limited by soil which is scarce and of low fertility, and an interior short summer continental climate (**Dfc** according to Köppens' classification).

Mines, towns and farms interspersed in the cut-over forest occupy but a small percentage of this area. The largest and most continuous area of development is a basin of farm land found six miles northwest of Sudbury. Most of the Sudbury Area is occupied with cut-over forests, lakes, swamps, and rock outcrops. Here man's imprint is the devastation caused by uncontrolled cutting of trees, by fires and by ruthless trapping.

The population pattern is spotted and the density low. The greatest concentration is in Sudbury, the dominant trade center, and in the smelter towns of Copper Cliff and Coniston. The second greatest concentration is the rural population in the Sudbury "pocket."

The Sudbury Area contains six distinct landscapes:

1. Saxicultural Landscape.
2. Agglomerated Agricultural Settlement of the Sudbury Pocket.
3. Dispersed Agricultural Settlement.
4. Sylvicultural Landscape.
5. Urban Landscapes.
6. Transportation and Communication Nets.

The first three are discussed.

Within a radius of twenty-two miles of Sudbury are found six active mines, three active smelters and one of the five refineries producing over four-fifths of the world's nickel and a large quantity of copper. In addition to the six active mines there are within this area thirty-eight abandoned or inactive ones. Some inactive mines contain large potential ore reserves.

There are two distinct rural landscapes developing within a few miles of each other in the Sudbury Area: the "Agglomerated Agricultural Settlement of the Sudbury Pocket" and the "Disseminated Agricultural Settlement of the Ice-scoured Hills." These settlements represent two of the most prevalent agricultural types in the Laurentian Highlands. Although both settlements are developing under similar climate, produce similar crops and market similar products in the saxicultural communities, they are distinctly different in landforms, soil, road pattern and stage of development.

Because of the limitations of climate, soil and landforms, agriculture in the Sudbury Area is not likely to become of primary importance to the Dominion in the near future. Here agriculture is marginal in character and primarily depends upon the saxicultural development for its existence.

The quality, quantity, type, and distribution of ore have been dominating factors in producing the cultural forms in the Sudbury Area. With large

potential reserves of ore and with an increasing demand for nickel, the saxicultural industry should continue to expand and prosper.

CLARENCE E. BATSCHELET AND MALCOLM J. PROUDFOOT.
The History of Area Measurement.

PART I

The concept of area and position on the earth is fundamental to geography. The measurement of large areas required maps based on an accurate understanding of the shape and size of the earth. Greek philosophers and mathematicians (Pythagoras, Aristotle, Eratosthenes and others) established the basic concept of a spherical earth and calculated its dimensions. The intellectual retrogression of the Middle Ages submerged this concept which was reawakened in force by the fifteenth and sixteenth century voyages of discovery, the revival of the cartographic work of Ptolemy and the theories of Copernicus. Geodesists and mathematicians (Snell, Picard, Newton, Cassini, Huyghens, Bessel, Clarke and Hayford) since the end of the sixteenth century, working with improved instruments, have established earth dimensions of remarkable accuracy, which in turn have allowed for accurate maps and tables giving the areas of quadrilaterals of latitude and longitude, and thereby laid the foundation for accurate area measurement.

Area measurement has progressed from unmeasured concepts of distance: to the measurement of small surveyed plots of land in Egypt and Babylonia; to comparisons of the length and breadth of countries and continents; to laborious calculations based on subdividing areas, especially along their boundaries, into smaller and smaller geometric figures and the measurement of average widths from a base line; to the use of transparent templet grids; to the weighing of map portions and computation of their area from the ratio of their weight to the weight of a known map area; to, finally, the invention of the polar planimeter used in conjunction with accurate area tables for quadrilaterals of latitude and longitude. Geographers, merchants, and army officers (Maylines, Halley, Templemann, Behm, Wagner, Supan, Trognitz, Haack, Strelbitsky and Penck) contributed to this long development by making many basic measurements and particularly by stimulating interest in the densities per unit area of a multitude of recordable phenomena.

PART II

Area measurement in the United States, as in Europe, awaited the construction of accurate maps. These maps resulted from the efforts of the U. S. General Land Office, the U. S. Geological Survey, the U. S. Coast and Geodetic Survey and the Engineer Corps of the U. S. Army. The first

area measurements, which were released in the annual report of the General Land Office in 1850 and followed by other area measurements at annual intervals, were culminated by the basic measurements of Henry Gannett released in 1881 for the Tenth Census of the United States. Gannett's work for the first time provided areas for every state and county and used the approved combined method of area tables for quadrilaterals of latitude and longitude and the polar planimeter for measuring irregular areas. Since that time American contributions to area measurement were made for each census by Henry Gannett assisted in recent years by C. S. Sloane, and, independent of the Census, by F. Bond of the General Land Office and F. J. Marschner of the Department of Agriculture. Currently, the Census Bureau has completed the first basic remeasurement in sixty years of the areas of the states and counties and the initial measurement of the areas of the some 50,000 minor civil divisions of the United States. These measurements, based on the U. S. Coast and Geodetic Survey 1 : 500,000 aeronautical charts of the 1937 edition, used area tables for 30-minute quadrilaterals of latitude and longitude and planimeter measurements for all irregular areas. Large-scale county maps were measured to obtain the minor civil division areas. County areas were adjusted to state areas and minor civil division areas were adjusted to county areas. The principal innovation is a set of standard definitions for land and water which provide an objective system for establishing the outer limits of the United States. It is hoped that a modification of these definitions might gain international acceptance and serve to standardize the remaining principal point of variance in the measurement of geographical areas.

ALFRED W. BOOTH. (Introduced by Preston E. James.)
An Area Analysis of Decatur County, Georgia.

A. Current Problems

The basic problem of Decatur County is that of over-population, a problem which has arisen as a result of:

1. The inability of the area to compete with other areas under present economic conditions.
2. A lack of efficient utilization of declining basic natural resources.
3. The felt need of its people, patricularly the young, for higher standards of living. Thus far, migration, again particularly of the young, has been the natural and oversimplified solution. However, such problems as:
   a. Readjustment to this new economy of "more for fewer."
   b. Preparing the young for life elsewhere.
   c. Carrying on local government without stripping it of useful functions.

are among those which have arisen from this outward movement of population.

Most of the problems of the area are being attacked, some rather vigorously, by various groups, private and public, county, state, and federal, with varying degrees of success. The present defense boom has also resulted in at least a temporary alleviation of some of the worst problems.

B. Directions of Readjustment

Most of the current trends within the area are toward a better and more stable economy. In agriculture, the chief trend is toward a reduction of number of farms without a reduction in crop acreage. This has been made possible by crop diversification and mechanization, and has resulted in a reduction of share-tenancy. Other agricultural trends, such as increasing specialization in crops other than cotton, increasing farm food self-sufficiency, livestock production, and sustained-yield forestry are also taking place.

In industry there has been a slight trend toward greater stabilization of employment. This is resulting in higher average wages, and simultaneously, in a sloughing off of purely seasonal workers. The need for noncyclical industries is felt, but local capital and management needs outside assistance to establish these new endeavors.

To encourage and direct these trends, responsible agencies must continue their efforts. Further research in farm and crop problems is necessary. Cooperative marketing and buying, canning, and cold storage projects should be established. More efficiency in local government through consolidation of conflicting county, city, and military district functions is possible.

Henry J. Bruman. (Introduced by Carl O. Sauer.)
The Sixteenth Century Relaciones Geográficas for Mexico.

Through his Council of the Indies, Philip II of Spain in 1577 issued an order to the officials of all major settlements in the Spanish colonies to send in answers to a carefully composed questionnaire of fifty subdivisions, pertaining to local matters of geography, history, anthropology, and agriculture. The answers were to be used by the royal chronicler in writing a detailed description of the Spanish possessions. Emphasis was placed on matters relating to aboriginal life, and it was ordered that the elders in each locality be called in to act as informants. Between two and three hundred of these answered questionnaires, which have become known as "*relaciones geográficas*," are still in existence, and they represent a store of historico-geographic information that has been largely neglected. They vary in

length from two or three brief pages to magnificent accounts exceeding fifty pages of manuscript.

All the Mexican *relaciones* now known to exist (a minimum of 166) are available in some form in the United States. At least 113 of them have been published, and are to be found in some of the more complete Latin American collections. The Library of the University of Texas has 31 originals that are as yet inedited, and the Department of Geography of the University of California has microfilm copies of 22 others, the unpublished originals of which are located in Spain. Lists of these *relaciones* made in the 16th and 17th centuries give several dozen more for Mexico than we can now locate, and we must assume that most of these have been lost. Some of the material in the *relaciones* no longer available was used in unmistakable form by the chronicler Herrera in his *Historia General*. . . .

Among the items concerning which the accounts are especially informative are (1) the distribution of native tribes and languages, (2) pre-Columbian history, tradition and mythology, and (3) the use of food and drink plants and the distribution and utilization of wild economic plants. The documents are particularly important for regions remote from the foci of Spanish interest, areas generally neglected by the historians of the 16th century. For Mexico detailed reports from a closely spaced net of stations are unusually valuable because of the intricate splitting-up of natural and cultural landscapes. Only for Yucatan are the *relaciones* of less individual significance,—relative uniformity of land and culture, the availability of other comprehensive accounts, and the presence of one outstanding informant who had a hand in writing about a dozen of the *relaciones,* all making for a lesser degree of individual variation and worth.

Much of the information in the *relaciones geográficas* is still relevant to the present scene, and much of it is invaluable for tracing the pattern of historic change.

MEREDITH F. BURRILL.

Land Classification in the Matanuska Valley.

The Land Classification Division of the General Land Office, set up recently to do classification of public lands, began such work in Alaska in 1941, to provide factual information on land use capabilities. The field problem was to determine and map the use-capability-types of land in the Matanuska Valley, based on the physical characteristics and use-history of the land. An examination of the use of patented and entered lands was related both to use-capability and the operation of the homestead laws. This region was studied first because it has the best combination of climate,

soils and accessibility and has many practical advantages for an initial investigation.

Three graduate student geographers employed as temporary field assistants and the writer formed the field party.

The Matanuska Valley lies in the south central part of the main block of Alaska, in latitudes 61° 20′ N. to 61° 45′ N., and longitudes 149° W. to 150° W. In its 400 square miles there are about 2,000 people and more than half of the Territory's 7,305 harvested crop acres. It lies between two high mountain ranges, the Chugach on the south and the Talkeetnas on the north and is the northeastward extension of the great Cook Inlet trough. It is connected with the Copper River basin by a low pass. The Alaska Railroad furnishes connection to Fairbanks, Anchorage and Seward, the rail-steamship junction. The highway from Anchorage is being extended to the Richardson Highway and a connection with the Seward-Sunrise Highway will probably come soon. These transportation lines are of great significance in marketing the Valley produce. Dominant vegetation is birch-spruce association with large areas of muskeg and black spruce. Natural grasslands occupy intermediate slopes on the mountains. The principal factor in soil productivity is the thickness of the windblown cover of material picked up from river beds and carried some miles out across the Valley. Such dust storms occurred on about half of the days this summer. Fields unprotected in winter often suffer considerable wind erosion. Numerous scattered areas remained frozen throughout the summer. Soil temperatures showed great variation and undoubtedly are important in land productivity there.

Because of their windblown mantle, land forms in the eastern part of the Valley are significant chiefly in their slope. In the western section none of the land forms appear to have great use-capability for agriculture. The study of land ownership and tenure was begun in the office from the tract book records and continued in the field. It was not possible to trace the use history and yields of specific fields with sufficient accuracy, so the present use of Valley lands was mapped completely and is being correlated with the types of land.

F. A. Carlson.

American Settlement in Isla de Pinos, Cuba.

Significant problems and trends of American settlers in the Caribbean are clearly exemplified in the Isle of Pines. During the period from 1800–1900, the total population of the Isle of Pines ran from 2,000 to 2,200 of whom about ten were Americans and much of the Island was in a state of neglect and decadence. By 1910 some 5,000 Americans had purchased

land in the Island and about 2,000 had come there to make their home. In 1935 the American population had shrunk to 275 and many of the investors had allowed their property taxes to become delinquent. The citrus industry, that was to have made so many American fortunes, had been reduced from 4,000 acres in 1910 to less than 1,000 acres in 1935. The causes of the decline of the American settlements, are, as they usually are, geographical, economic, social and political. However, as a single element it may be said that climate has been over emphasized as a causal factor for the waning stage of American interest in the Island. In the course of the next generation or two it is almost certain that the last vestige of the former American settlement will be assimilated by Cuban culture and influence; that the Island population will become predominately one of mixed races, the whites being absorbed or driven out; that the Island's economy will be in the hands of the new ethnic groups and that opportunities for foreign investors will not be encouraging. Evidence based on American settlers in other parts of the Caribbean seem to indicate that they do have or will encounter similar problems. That the Caribbean is destined to become a region of mixed races and one of local control of social, economic, and political affairs is beyond speculation. Uncertainty, however, may be voiced as to the future civilization of the Caribbean. Will the new ethnic groups lower the present forms of culture? On this point the existing scientific views are conflicting and vague. Based on limited data and observations there is some reason for predicting that through expert supervision of health, hygiene, sanitation, nutrition, education, and particularly economy, the way of life in the Caribbean will not lower but raise its present plane of Civilization.

WILLIAM F. CHRISTIANS. (Introduced by Frank E. Williams.)
The "Line-Block" Traverse—An Experimental Field Technique.

The "line-block" traverse is a combination of the usual traverse method of field mapping with small, intensive, areal surveys interspersed at regular intervals.

The technique has a twofold objective: (1) to gain a higher degree of accuracy in geographic field surveying than is possible through the use of the traverse alone, and (2) to achieve more rapid coverage than is possible when detailed mapping of a large area is attempted. It is felt that the method has sufficient flexibility to be applicable to a wide variety of geographic field studies.

The technique was tried out during the past summer in the Ridge and Valley country of Pennsylvania. The area studied covered approximately 2500 square miles and included portions of the anthracite coal fields as well

as sections devoted to agriculture, forests, and urban centers. No large cities were included in the survey, but some small urban communities were studied in detail.

The region seemed sufficiently complex, both in its land-use pattern and in its physical character, to afford a good test of the technique.

The paper presents a brief explanation of the method, indicates some of its possible applications as well as its flexibility, and, by means of samples of studies made in the field, illustrates the nature of the results obtained through the use of the technique.

JOHN WESLEY COULTER.

Changes in Land Utilization in South Sea Islands.

The sending of missionaries from Europe to the far-flung South Sea Islands at the end of the eighteenth century and the beginning of the nineteenth soon resulted in the conversion of the natives to Christianity. With the adoption of the new religion the brown-skinned people took on clothes, and other manners of the west. Various other transformations in their ways of living took place. Among the last things to change are their methods of land utilization. Western methods of farming now being adopted mark the complete breakdown of native island civilization, and the beginning of a new method of life ill suited to the temperament of the indigenous people. Land in the South Sea islands has been traditionally held in large areas owned by clans or tribes which raised subsistence crops under a cooperative-communal system of agriculture. Clearings were made in the forest by girdling the trees or by burning the bases of the trunks; two or three crops were raised in the clearing after which it was abandoned to allow the soil to recuperate. Many tree crops were volunteer growths sprung from shoots or from fallen seeds. The forest afforded useful products without requiring any replenishment. These methods of land use worked satisfactorily because of the small density of population in the islands and a large area of agricultural land. Tribal wars and a high mortality rate held the population in check. On many islands in the South Seas large blocks of land are now being broken up into small farms owned in fee simple by individuals. Attempts are being made to teach natives regular tree-crop planting. Systems of land tenure are similar to those in Europe and America. Commercial agriculture is carried on. Among the reasons for these changes is the increase in population, and therefore a greater pressure than formerly on the means of subsistence. The increase in population has been made possible by a regime of peace and by improvements in health and sanitation. In Fiji an important reason has been the establishment of East Indians as peasant farmers, and the consequent necessity of making indi-

vidual farmers out of the native Fijians, so as to help them to hold their own in conflict with a new and alien culture. Another reason for the change in land use is contact with western people who own and operate land in the islands in their traditional way. The necessity for money is a reason for commercial agriculture. These changes do not fit the philosophy of the natives of South Sea Islands. The idea of being alone, independent, and non-cooperative generally in dealings with fellow men is not part of their social psychology. The result of individualist ventures is that the old indigenous social and economic system is breaking down. Dwarfed and condemned by individualism, the cooperative-communal system has disintegrated. There is no evidence that the economic system of western civilization can be imposed on a native people with advantage to them.

George B. Cressey.

Land Form Regions of New York State.

Within New York are all or parts of 9 geomorphic provinces and 31 regions. These are shown on maps to be displayed at the New York meetings, mimeographed copies of which are available for distribution. While the primary classification is in terms of land *form,* the areas also reflect lithology, structure, and geologic history. The terminology of surface configuration needs standardization; as here used the provinces are termed lowlands, uplands, or highlands, largely on the basis of relief. The regions are generally named plains, hills, or mountains in terms of slope, in some cases with a genetic adjective such as *lake* plain. The term valley is applied to coherent regions of related land forms.

The Adirondack Highlands are coextensive with pre-Cambrian rocks. Within the province are three regions: the Adirondack High Peaks, which include all summits over 3,000 feet, the encircling Adirondack Low Mountains with a more or less even skyline and elevations over 1,500 feet, and the Western Adirondack Hills.

The St. Lawrence-Champlain Lowlands are divided into the St. Lawrence Marine Plain, the St. Lawrence Hills to the south, and the Champlain Lake Plain.

The New England Uplands along the eastern border of the state may be divided into the Taconic Hills, the Berkshire Hills, the Reading Hills, and the Manhattan Hills. Between the last two regions is the end of the Triassic Lowland province. The Harbor Hill-Ronkonkoma Moraines and the Long Island Outwash Plain are regional units of the Atlantic Coastal Lowlands.

The Hudson-Mohawk Lowlands include the Hudson Valley and the Walkill Valley, continuations of the Valley and Ridge Province, and the Mohawk Valley.

The Appalachian Uplands form the largest province in the state; with traces of the Schooley peneplain on the upper surfaces. In the east are the Catskill Mountains, south of which are the Delaware Hills and the Shawangunk Mountains, while to the north are the Helderberg Hills. Farther west are the Susquehanna Hills, the Finger Lake Hills, and the Cattaraugus Hills, each with undissected rolling plateau areas and with deeply glaciated "fiord" valleys in the center. The unglaciated Allegheny Hills lie in the southwest. The Tug Hill Upland is an outlier of the Appalachian Uplands.

The Erie-Ontario Lowland has eight regions. The flattest areas are the Erie Lake Plain, the Ontario Lake Plain, and the Oneida Lake Plain. The Southern Ontario Hills lie immediately north of the Allegheny Front in the west, while farther east are the Ontario Drumlins, the Ontario Ridge and Swamp Land, and the Eastern Ontario Hills. The Black River Valley is an extension of the province.

George B. Cressey.

Siberian Resources for Soviet Warfare.

During the three Five Year Plans, 1928–1942, the Soviet Union has endeavored to "develop the productive resources" of all parts of the Union. This has enormously increased mineral production, industrial output, transportation facilities, and urbanization in the Ural Mountains and Siberia. The strategic value of these developments in the war with Germany is obvious. It appears probable that the industrial capacity of this area is adequate for a significant defense output even though all of Soviet Europe should be occupied.

While a pioneering economy still characterizes many regions of Soviet Asia, significant industrial centers have arisen around many cities, 10 of which exceed 200,000 population. Railway mileage has been doubled, and includes numerous lines of strategic importance. Much of this growth is based on mineral wealth which in turn supports heavy industry, the chief objective of the Five Year Plans.

Coal reserves account for 90 per cent of the Union's 1,654,361,000,000 metric tons, and the annual Asiatic output is approximately forty million tons, or 30 per cent of the Union total. Half of this is from the Kuznetz field of central Siberia. In the Urals bituminous coal is mined at Kizel and lignite at Chelyabinsk; to the east are the Karaganda, Cheremkhovo, Bureya, and Vladisvostok fields.

Petroleum production is rapidly increasing in the Emba area northeast of the Caspian, and between the Volga and the Urals. No important reserves are known in Siberia, except on the island of Sakhalin.

Iron ore is produced at three major centers in the Ural Mountains: Nizhni Tagil, Zlatoust, and Magnitogorsk. There is also an important output south of the Kuznetz Basin, and new mines are producing near the Amur River. Siberian production amounts to a third of the Union total. Low grade manganese is obtained in the Urals, in Kazakhstan, and near the Kuznetz Basin.

Copper is secured from porphyry deposits at Kounrad and Djezkazgan near Lake Balkhash; various types of ore are also mined in the Urals. Lead and zinc have long been produced at Ridder in the Altai Mountains. Bauxite deposits of fair quality are worked in the Urals. Gold is produced from lode deposits in the Urals and from placer deposits on tributaries of the Yenisei and Lena Rivers, notably the Aldan; foreign estimates place the annual production at 5 million ounces.

Exceptionally large reserves of potash are present at Solikamsk in the northern Urals, with a production of 2 million tons. Other minerals include asbestos, magnesite, platinum, and chromium in the Urals, and nickel in the Urals and Yenisei Arctic.

LOYAL DURAND, JR.

Dairy Barns of Southeastern Wisconsin: Relation to the Dairy Industry and to Regions of "Yankee" and "German" Settlement.

The dairy regions of Wisconsin possess farm buildings of uniformly high quality. Barns are especially large and conspicuous features of the landscape, and are notable enough so that even the cursory tourist is wont to remark upon them. Southeastern Wisconsin appears upon a map of "value of land and buildings" as one of the outstanding agricultural sections of the United States. Yet when "land" and "buildings" are separated the southeastern Wisconsin area cannot hope to compare in physical quality with the land of the Corn Belt; it is the fine farm buildings of southeastern Wisconsin that help to place the area in high estate upon a map of national farm valuations.

The large barns of southeastern Wisconsin have been built in response to the prevailing farm occupation of dairying. They are not due to racial characteristics of the population; in other words the oft-heard statement that "farming sections peopled by inhabitants of German descent have the best barns" does not prove true in fact. Barns are equally large, substantial, and in good repair in all sections, whether settled by Yankees from the East, Scandinavians, Germans, Welsh, English, or others. Determining factors in their size and omnipresence are the occupation of dairying, the large herds, high farm incomes, and the long winter feeding season, necessitating large storage space for hay.

In order to prove or disprove the supposed relationship between Germans and existence of large barns the writer conducted field work in tiers of townships stretching from the Illinois state line northward to the latitude of Lake Winnebago. The townships thus crossed a significant cultural-historical border in Wisconsin, for south of the latitude of Milwaukee the prairies and oak openings were settled predominantly by eastern Americans, while north of the latitude of Milwaukee the large lakeshore German colonies of Wisconsin were planted. The townships thus chosen crossed the border between farms operated by Americans of several generations, and third (occasionally fourth) generation Americans of German descent. Photographs were made of the barns at the center of each township—the picture was taken at the corner of sections 15, 16, 21, and 22, or of the farm closest to the corner. In this way the subjective element was removed, and a sampling obtained at six mile intervals for a distance of eighty-four miles north of the state line.

Studies of farm ownership, present and past, in the four center sections of each township provided information as to racial and language groups of each sampling. If possible the history of the farm at the center was traced. In this manner evidence as to the barns of the "non-German" and "German" sections was accumulated.

Barns are equally good in all sections sampled. All peoples have built large, substantial dairy barns. Rather than associating prominent barns with Germanic peoples, the fact seems to be the association with the prevailing and intensive Wisconsin rural industry of dairy farming.

FRANCES M. EARLE. (Introduced by Guy-Harold Smith.)
The Ainu of Northern Japan—A Remnant Race.

Of the historically famous Ainu of Japan only 15,000 remain—about 1,000 in Karafuto and the others in Hokkaido where they tend to concentrate in the forested areas on the north shore of Volcano Bay, on the Hidaka Coast, in the Tokachi Basin, and near Asahigawa.

Prior to the coming of the Japanese the Ainu inhabited the entire archipelago. For centuries these hunters and fishermen of powerful physique resisted subjugation. Eventually defeated, those who refused to submit to the Japanese moved northward.

Hokkaido was thickly forested and well supplied with deer, bear, foxes, and otters; with ducks, geese, and swans; with salmon, herring, and other fish. There were chestnut and walnut trees as well as fir, elm, poplar, birch, and yew. Houses were built of local reeds or wood, and elm bast and skins were made into clothing. The Ainu obtained a good subsistence and traded surplus dried herrings, skins, and feathers for Japanese axes, knives, rice,

tobacco, textiles, and lacquered containers. In making their adjustment to this cold northern environment the Ainu have become thoroughly acclimatized.

In the Meiji era Hokkaido has had a great influx of Japanese settlers and has become a region of resource exploitation and pioneer agriculture. As increasing areas were timbered off and the best lands cultivated, the areas available for hunting and fishing diminished. Fish and game decreased. Unable to resist encroachments of a more energetic and industrious race, the Ainu have been pushed into the poorer areas. Their economic life is being seriously affected and the birth rate has declined to the point where their problem is racial survival.

The Ainu have made certain adaptations to the more complex society of their Japanese neighbors. Some practice small-scale farming while others work as laborers in mines, commercial fisheries, forests, and pulp mills. Only a few have been able to obtain sufficient education to compete in business or the professions.

Their status as a subject race is felt keenly by most of the Ainu. The patriarchs try to keep old ceremonies and customs alive but the younger people doubt their efficacy and are trying to Japonize themselves. Younger men cut their hair, shave their beards, and adopt Japanese dress. Women no longer have their hands and mouths tattooed and are usually eager to marry Japanese, thereby improving their social and economic position.

Assimilation has been proceeding steadily, through intermarriage and by Ainu adoption of Japanese children. Many authorities believe that complete assimilation and racial disappearance is the kindest solution of the Ainu problem. Others believe they should be protected on government reservations as a unique example of neolithic culture. Whatever their future, the Ainu present the familiar spectacle of a primitive people in competition with a group having a higher type of culture.

FRANKLIN C. ERICKSON. (Introduced by Preston E. James.)
An Area Analysis of Chatham County, North Carolina.

A. Directions of Readjustments.

The main problem is how to improve farm, forest, and industrial conditions and raise the general standard of living of the people. This means the development of the dairy and poultry industries, which are at present limited due to markets, quality of stock and poultry, conditions of the farms, labor conditions, and inadequate electricity.

The improvement of the forests cannot be brought about unless education and instruction in forest production and selective cutting is introduced and accepted. Reseeding of wasteland, State fire protection, and laws

regulating size of timber to be cut, as well as the establishment of a C.C.C. unit would also be effective.

Industry suffers due to market and labor conditions as well as differentials in freight rates.

Competition from surrounding regions must be met.

B. Recommendations.

1. Achieve a sound economic basis for agriculture by continuing the various agencies within the Department of Agriculture. This would permit loans for the development of dairy and poultry through:
    a. Purchase of good breeding cattle.
    b. Construction of barns and buildings.
    c. Fencing lands.
    d. Extension of electric lines.
2. Achieve a balanced forest economy by:
    a. Adequate fire protection.
    b. Education in forest protection and selective cutting.
    c. Reseeding of wasteland.
    d. Placing of a forester with the extension division to work in the county and carry on an educational program.
    e. Establishment of a C.C.C. camp within the county.
3. Aid industry by:
    a. Adjusting freight rates.
    b. Permitting a greater number of apprentices in various industries.
    c. Marketing research.

J. Sullivan Gibson. (Introduced by Preston E. James.)
An Area Analysis of Sumter County, Alabama.

A. Current Problems.

Two sorts of current economic problems prevail in Sumter County:

1. Problems related to conserving the natural resources and rebuilding losses due to over-use and careless handling.
2. Problems related to developing a new farming system to take the place of cotton farming.

Through some gullying, serious sheet erosion, and excessive exhaustion from continuous cotton planting, soils have deteriorated tremendously. Without fertilization calcareous soils yield only one-fourth to one-half as much cotton per acre as they produced a half-century ago. Sandy acid soils approach more nearly their original yields. Erosion should be checked and fertility restored through systematic handling.

Fully three-fourths of the farmers of the county, including practically all Negro tenants, are unable to turn successfully and unaided to any farming system different from cotton farming. The rising cattle industry is displacing the Negro, for he knows no other type of work than cotton farming. Close supervision through a long period of years, a small amount of capital, and a new credit system are necessary to fit him into a new program.

B. Recommendations.

1. Improve agricultural economy.
    a. Continue soil conservation program. Instruct carefully land owners and tenants in keeping terraces repaired. Make maintenance obilgatory for further government aid.
    b. Supervise closely Social Security clientele.
    c. Reduce direct relief, and for a large part of it substitute instruction and supervision in home production, preparation, and preserving of food. Correlate this work with that of Social Security Service.
    d. Aid in developing a fluid-milk market, *e.g.,* establish a County sub-station and collecting service in cooperation with the condensery at Macon, Mississippi.
    e. Establish a canning plant in the Cuba area, Southern Sumter County, to utilize and encourage the bean crop.
    f. Expand 4-H club work throughout the County.
2. Improve forest economy.
    a. Improve forestry program, providing fire protection and forest management service.

EARL PARKER HANSON.

Problems of the United States in Puerto Rico.

That the specific forces of colonialism which we instituted in Puerto Rico after the Spanish American War have about run their full course is indicated by the fact that for the past eight years the island has been artificially supported by the U. S. Government, through various forms of relief, attempted reconstruction, and defense expenditures.

A fundamental evil is the unequal distribution of land, under which absentee-owners of illegally vast estates raise cash crops to be exported in return for finished products, but export profits as well as products. Symptoms are: widespread and permanent unemployment, an apparently permanent unfavorable balance of payments, and an average mortgage debt on the Puerto Rican owned coffee lands of about 80% of assessed valuation. Of

the four major crops, only coffee is predominantly in Puerto Rican hands. and the coffee business is ruined.

Because of its cash crop economy, Puerto Rico is our second best customer for U. S. goods in the Western Hemisphere; however, the tariff barrier and inclusion of the island in the terms of the coastwise shipping laws make for high local prices, which, when combined with unemployment and the lack of land on which to grow food, add to the widespread suffering and unrest.

Medical men consider a major disastrous epidemic in Puerto Rico almost inevitable. Figures show that the island has about the world's highest incidences of malaria, tuberculosis, and hookworm—all caused by abysmally low standards of living.

Efforts to create employment and better the balance of payments through local manufacture have largely failed in the past because the island's political and economic situation make it too vulnerable to dumping from the mainland. That situation also militates against the reinvestment of local capital in local enterprises.

The unresolved political status (admittedly temporary) adds to the confusion. The constant clamor for some form of permanent political status has its roots in the island's almost universal suffering and is based on the knowledge that no permanent improvement can be achieved unless the political situation is first stabilized. Under present conditions, what one congress may legislate for Puerto Rico's benefit, the next may undo, so again discouraging any effective investment of money or labor in Puerto Rico's future.

WALTER HANSON. (Introduced by Preston E. James.)
An Area Analysis of Denton County, Texas.

A. Current Problems.

How to provide a decent living for all farmers and at the same time establish a comprehensive program of soil conservation. This will involve:

1. A general increase in the size of farms under 160 acres.
2. Providing work in towns and cities in this County or elsewhere for those eliminated from some of the small farms.
3. Parity prices for farm products.
4. Increasing the number of farm owners who live on the farm.
5. Long term written rental agreements.
6. The farm program must be made attractive enough to hold more of the young men of ability and vision on the farm. At the present half of the land owners are over fifty years of age and in many cases are unwilling or slow to change their system of farming or to cooperate with the soil conservation program.

7. In general, farmers should think more in terms of making *a good living permanently* and less of making *money* from the farm.

B. Recommendations.

1. Establish a long range policy of soil conservation for Denton County as a part of the recently organized Conservation District and along lines recommended by the Soil Service.
2. Retirement of much of the poorer land from cultivation—more pasture with greater emphasis on dairying and poultry production.
3. Take care of future unemployment problems by offering work in the conservation program for all permanent residents who are not otherwise provided for.
4. Make farm life more attractive for everyone, especially for the young farm people, by extending or initiating the following: A greater variety of sources of income, plus crop insurance, so as to make a good living certain every year; Better homes, with electricity, running water, and sanitary sewage disposal system; better balanced diet; a better health and recreational program, perhaps with free medical and dental care for all school children; vocational guidance—both along agricultural lines and to take care of the surplus farm population.
5. This County needs more school teachers and preachers who are capable and willing to assume leadership along the lines of the Soil Conservation Program, the AAA, FSA, and the philosophy of Agriculture, as expressed in the last three issues of the *Yearbook of Agriculture.*
6. With nearly a third of all farm families moving every year, there is a need for long term written contracts while the program of owner-operator is being developed.
7. Continue to standardize and restrict the use of grain seeds and breeds of livestock and poultry.

CHAUNCEY D. HARRIS. (Introduced by Nels A. Bengtson.)
A Functional Classification of Cities in the United States.

American cities may be classified in five functional groups: manufacturing, wholesaling, retailing, diversified, and special with letter designations **M, W, R, D,** and **X** respectively. Examples of each functional type are: **M,** Philadelphia, Detroit, Pittsburgh, and Providence; **W,** San Francisco, New Orleans, Denver, and Dallas; **R,** Wichita, Lincoln, and Madison; **D,** New York, Chicago, St. Louis, Atlanta, and Houston; and **X,** Washington, and Los Angeles.

The classification is based on the per cent of the total employment in industry and trade which is engaged in manufacturing, wholesale trade, and retail trade in each of the 140 metropolitan districts defined by the 1940 census. Employment figures compiled from the Census of Manufactures and the Census of Business are used in preference to occupation figures as given by the decennial census, since the former are superior in separating wholesale and retail trade, in giving a more critical figure for manufacturing, and in recording place of work rather than place of residence. No figures are available by functional units, but by adding together employment figures for each of the component areas of a metropolitan district, it was possible to approximate the employment in each urban district.

Most of the manufacturing cities are in the northeastern section of the country, but there are eight in the southeastern states. The wholesaling centers are ports or regional capitals outside of the manufacturing belt. The retail centers are smaller towns. Diversified cities are largely in the Middle West and the South. Special cities include a number of resort towns in California and Florida.

RICHARD HARTSHORNE. (Invited paper.)

The Nationality Problem in the Shatter Zone of Eastern Europe.

For the United States, the nationality problem of Eastern Europe is of concern when instability in that region can be exploited by any power able thereby to gain mastery of the continent of Europe and also to attain a major position as seapower in the Atlantic. Throughout most of our history this has not been possible, though Napoleon might conceivably have attained it. Early in 1917 it was a real possibility, because of the military success of Germany at the time when Austria-Hungary was disintegrating internally. The obvious result of the last war was to complete the century of disintegration of imperial control over subject peoples in east central Europe from the Baltic to the Aegean but in terms of geopolitical power, this meant that the way was open for Germany, once its military power was regained, to expand her power over the greater part of Eastern Europe and then on this basis to dominate the entire continent and become the most powerful seapower in the Atlantic.

The difficulties that disturbed the situation in this part of Europe in the period 1920 to 1938 demonstrated that the application of the concept of the sovereign national state, as developed in Western Europe, could neither satisfy the desires of many millions of minority peoples inevitably included in states dominated by another nationality nor provide the economic basis for well-being in a region of so many small national units. The catastrophe

that began with the German advance into this region in 1938 however was essentially independent of these difficulties, but demonstrated that the system of small independent states each asserting independent sovereignty was unable to defend itself against a major neighboring power and that it was too easy for the more remote western powers to forget that their own security depended on the security of these small states of Eastern Europe.

A more secure system in Eastern Europe must therefore provide some organization of larger areas able to provide more effectively for their own defense as well as for their economic well being. Such a system must recognize the geographic impossibility of marking off in even approximate degree boundary lines between different nationalities, comparable to the boundary lines of western Europe. But it must also accept the reality and importance of national differences and provide a political framework in which these may find proper expression if it is to be accepted permanently by the peoples concerned. Finally it must recognize the fact that the location and resources of Germany make that country the natural leader in the foreign trade of that part of Europe and at the same time enable it to destroy any system set up in that region unless specific measures are provided and maintained to prevent that result. These conditions present a host of geographic and political questions that should be studied before plans are formulated for political reconstruction of this critical part of the world.

LESLIE HEWES. (Introduced by C. W. Thornthwaite.)

The Eastern Border of the Cherokee Country of Oklahoma as a Cultural "Fault Line."

The Cherokee Ozarks, the eastern portion of the Cherokee Nation and a portion of the former Indian Territory, have had a unique history, which has affected the regional economy and landscapes profoundly. In economic development the area lags behind the immediately adjacent portion of the Ozarks in Arkansas and Missouri. The Cherokee Ozarks are somewhat less densely populated, the rural land use is more primitive, farm buildings are poorer and less well kept, towns are fewer and smaller, and there is less trade.

The inter-regional differences in density of population and in percentage of the land in crops are not great, and may be approximately in proportion to differences in land resources. However, fenced pasture occupies only one-half as much land in the Cherokee Ozarks as in the four bordering Ozark counties, which have somewhat less area, and the Cherokee Ozarks contain at least one-half more unimproved land. In comparison to the border counties to the east, the Cherokee Ozarks grow more corn, less hay and small fruits, and have less than one-fifth as much acerage in or-

chards and vineyards. Field observations show that rural houses are smaller and less well kept in the Cherokee Country than immediately to the east. Only one town in the Cherokee Ozarks has over 2,500 inhabitants, as against five in the border counties; the total population of all incorporated places is less than one-half as great in the Cherokee Ozarks; and the average per capita retail sales in the Cherokee Ozarks are less than one-half as great as in the border counties.

There has been a large degree of pioneer survival in the Cherokee Ozarks, such as the raising of corn, dependence on the open range, and the use of log and other primitive house types. Pioneer conditions have survived largely as a result of the slow population increase, the large number of conservative Indians and of poor whites, who came into the region as renters of Indian land. Community land ownership until the allotting of land, 1903–1910, retarded the spread of fruit growing, which followed railroad building in the country to the east. A high degree of tenancy has continued to handicap the area. The need for towns in the Cherokee Ozarks was reduced by the dependence placed on trade centers to the east. The towns to the east continue to divert trade from the Cherokee Ozarks and to retard the growth of towns.

The eastern border of the Cherokee Country is a cultural "fault line" due largely to the unlike culture histories of the lands on its two sides. Thus, Indian occupance is a significant theme in the cultural geography of the Cherokee Ozarks.

Harry Eugene Hoy. (Introduced by Preston E. James.)
A New Map of the Surface Configuration of Mexico.

Map display only.

Ellsworth Huntington.
Geographical Distribution of Human Productivity.

Geographers are still sadly ignorant of human differences. We know how many bushels of wheat are grown in every part of the world. We know the relative productiveness of different varieties in all sorts of soils and climates. Similar knowledge of man's productivity and capacity is essential as a basis of any well-rounded human geography. Statistics which make such knowledge possible are gradually accumulating, and it is time to take stock of them. The League of Nations is the chief source of such statistics, but Colin Clark and S. K. Bennett have made valuable contributions. The available data give us an idea of the agricultural and industrial productivity per man or per worker in a considerable number of countries. Data as to income per person are at least roughly available for most

countries. The most outstanding feature of all these data is the enormous differences from country to country. Part of these differences are of course due to climate and soil, but part are more definitely human reactions. An analysis of the human factors begins with diet. Calculating this according to four different methods we find that the proportion of protective foods is extremely variable, and that the variations show strong resemblance to those of productivity and income. Similar statistics for medical care help to round out the picture. They show less relation to productivity than those for diet. The data as to diet and medical care give a picture of physical health in the different parts of the world. The beginnings of a similar picture of mental activity are found in statistics as to patents and education. Statistics of the kind here discussed and along many other similar lines are one of the most necessary as well as most neglected tools of human geography.

CLYDE F. KOHN. (Introduced by Preston E. James.)
An Area Analysis of Lowndes County, Mississippi.

A. Current Problems

The problems of this area are typical of those current throughout the South. During the past decade farm families have added greatly to the labor supply of the county, while, on the other, recent industrial expansion has not been able to absorb this increase. A tremendous pressure of population on the economic resources of the region has, therefore, resulted. A present airbase project tends to relieve this pressure to some extent, for much local unskilled labor is being used in clearing the land.

In the rural areas, several recent changes in land utilization are proceeding at a rapid rate. These changes have been brought about by variations in production practices, by the prices paid and received for cotton, and by the extent of participation of the agricultural adjustment and soil conservation programs of the Federal Government. A notable increase in dairying and beef cattle production, for example, has taken place in the prairie section since 1930, and further diversification is being advocated.

B. Recommendations.

The low-income agricultural group of Lowndes County has added to the task of the agencies of relief and reconstruction. Several proposals may be listed to help this situation:

1. Improvement of conservation practices on agricultural lands, including soil erosion control and reforestation.
2. A continuation of the CCC help in terracing, fire protection, gully control, fencing, brushing and grubbing, and other activities on the farm which demand too much of the operator's time and income.

3. Further promotion of diversified farming, including the raising of livestock.
4. Continuation of rehabilitation programs aiding the low-income farmers.
5. Discouragement of the farm-to-town movement. This may necessitate the development of a transportation system in order to allow factory workers to live on farms.
6. Promotion of cooperative devices, especially in the growing and marketing of a one variety cotton.
7. Promotion of mechanization and instruction in the use of this machinery.

HENRY MADISON KENDALL.

Surface Configuration of the Atlas Lands.

The usual treatment of the surface configuration of northwest Africa includes the notion of folded mountain ranges arranged along two east-west lines with one transverse connecting chain flanked by complementary plateaus. Fringing coastal plains are indicated at both western and eastern extremities. Maps show the Rif, the Tellean Atlas, the Middle Atlas, the High Atlas, the Anti Atlas, and the Saharan Atlas as mountains differing only in height. The Moroccan Meseta and the plateau of the Shotts are shown as plateaus on opposite sides of the Middle Atlas. The Moroccan and Tunisian plains complete the usually presented picture. Such a division leans on many criteria: some are observable as, for example, structure; others have no firmer base than the colloquialism of place distinction. In sum, they do not amply describe the broader surface units of the area.

An attempt is here made to recognize, on a continental scale, certain working divisions which will be more fully descriptive than those stated above. The elements of relief, structure, rock type, and type of erosive agent have entered into the determination. In illustration, the Moroccan Meseta is usually represented as a unit, a plateau lying between the Rif, the Middle Atlas, and the High Atlas and stretching westward, nearly to the Atlantic coast. Actually the area so classed is in part a true tabular upland, but much of its surface may more accurately be described as crystalline hilly upland. In addition the alluvial plains of Tadla, Bahira, and Marrakech lie between the upland and the mountains. Areally the tabular upland, the crystalline hilly upland, and the alluvial plains are nearly equal. The term Moroccan Meseta implies place and structure. It fails to convey even approximately the surface configuration. It is to correct such misconceptions that this attempt is made.

JOHN LEIGHLY.

The Climate of the Matanuska Valley.

Local differences in climate in the lowlands of Alaska are mainly dependent on the frequency of incidence of maritime air; and this frequency depends more on relief than on simple distance from the sea. The Matanuska Valley is a part of one of the two depressions of south-central Alaska that in position are intermediate between seacoast and interior, and that lie behind the first range of mountains.

This intermediate position does not result in values of the climatic elements that can be characterized simply as intermediate between coast and interior. Winter temperature, summer temperature, and annual precipitation can be taken as the three most conspicuous characteristics of the Alaskan climates. The mean winter temperature of the Matanuska Valley is nearly halfway between those of the mildest and the severest winters of the permanently inhabited parts of the Territory, which are experienced respectively in southeastern Alaska and in the valleys of the Yukon and the Tanana. The mean temperature of the summer is, however, about the same as at Juneau and Sitka, thus somewhat lower than the summer temperatures of the interior. Its mean annual precipitation is about the same as is observed in the interior. Thus the climate of the Valley is more nearly a combination of features of coast and interior than one that is strictly intermediate. A better combination of those qualities can be imagined, but is not to be found in Alaska.

The average circulation of the atmosphere over the northern edge of the North Pacific Ocean favors a dominance of maritime air in summer and an alternation of maritime and continental air in winter in the Valley. Enough maritime air moves northward over Cook Inlet in summer to produce a good deal of cloudiness and to keep summer temperatures relatively low. But the Chugach Mountains are a sufficient barrier to prevent the heavy precipitation that afflicts the coastal belt. Most of the continental air that in winter apparently occupies the Valley about half the time probably does not have its origin in interior Alaska, but over the mountains that surround the Matanuska Valley on three sides, and particularly over the snow fields of the Chugach Mountains.

HOYT LEMONS. (Introduced by Nels A. Bengtson.)

Hail as a Factor in the Regional Climatology of the United States.

In the Great Plains and Central Lowlands hailstorms are of such frequency and destructiveness as to constitute a major climatic hazard. An active hail area originates in the southern Plains in March and develops

northward with the season. After June, frequency diminishes rapidly although hail remains a menace until Autumn.

High frequency and northward expansion result mainly from (1) atmospheric instability and frontal activity, (2) surface heating effects of the apparently northward migrating sun and (3) levelness of the terrain from the Gulf of Mexico to Canada.

The late afternoon daily maximum frequency approximates the time of the daily maximum temperature; the accumulated surface heat aids the development of convectional currents. It is significant that hail damage is minimized due to the fact that it falls when the thunderstorm path is still narrow—one to two miles wide.

The Great Plains and Central Lowlands are severely afflicted because: (1) they are located in the principal hail region, (2) they contain the most extensive agricultural lands of the nation, (3) the period of maximum hail activity coincides with the period of growth of the principal agricultural crops. Hail is especially significant to the Great Plains farmer due to his dependence on one cash crop, usually a type highly susceptible to damage by hail. Since his economic eggs are all in one basket, a single capricious storm is capable of greatly reducing his buying power and inflicting acute social and economic consequences which are reflected in the financial, industrial and commercial realms of the region.

The recognized antidote for hail damage is hail insurance. Two basic requirements underlie successful adjustment of hail crop damage: (1) statistical data, (2) scientific knowledge of plant physiology as related to hail. Experiments show that (1) different plants vary in their degrees of susceptibility to hail damage and (2) plants differ at various stages of growth in their susceptibilities to hail damage.

A. K. Lobeck.

Geological Map of the United States.

A generalized Geological Map of the United States, scale 1: 5,000,000, based upon the United States Geological Survey. Map, scale 1: 2,500,000. Printed in two colors.

F. Webster McBryde. (Introduced by Carl O. Sauer.)

Highland-Lowland Cultural Contrasts among Southwestern Guatemala Indians.

Southwestern Guatemala's two major cultural regions coincide significantly with the two great climatic provinces. The division ranges essentially between the 1400- and 1500-meter isohypses. Above are the volcanoes and deeply-dissected, elevated ash plateau, covered principally with oak-

pine forests and bunch-grass, with mesothermal climate (**Cw**, Köppen); below are the well-watered piedmont, with heavy monsoon forest, and the coastal plain, park-savanna country with heavy gallery forests (**Aw**, Köppen).

Most highland Indians are economically independent, supplementing subsistence agriculture with diversified crafts, commerce, and sometimes seasonal labor on lowland plantations. They live in adobe houses, speak Maya dialects more than Spanish, and generally have special crafts and costumes distinctive to their home communities or *municipios,* often isolated cultural and economic units. Indian ownership of land and participation in local government are common. Deep hoeing or plowing, use of fertilizer, and one annual harvest characterize their agriculture, with corn (mostly flint) and beans (kidney and butterbean) comprising probably 90% of their diet. Wheat (mainly summer-growing), vetch, and sheep are also important. Markets are well developed, a consequence of regional diversity, and convene on various days of the week. Large fairs, usually dated by the Catholic calendar, are more commercial than religious.

Lowland Indians generally are subordinated, culturally and economically, to the aristocratic plantation owners, who grow primarily coffee, sugar, bananas, and rice. Lowland subsistence farming requires only *machete* for clearing, and *macana* or planting-stick. The rich volcanic alluvium is not fertilized, yet two, often three annual harvests are the rule, the corn, chiefly dent, and beans (kidney and lima) still the basic crops, supplemented by many more useful plants than are known in the highlands. Lowland Indians have few crafts, speak little Maya, and have interbred freely with whites. Their pole-walled houses vary with locally available construction plants; costumes are drab, little differentiated, and scanty. Sunday, offday for laborers, is the big market day all along the "coast." Villages, concentrated near the 350-meter isohyps, mostly off the railroad, are trade centers for coffee *fincas* above and cattle *potreros* below, where highland animals are driven for fattening. After coffee replaced cacao in economic dominance, around 1850, many lowland *municipios* split off from highland ones. In some cases highlanders retain purely Indian lowland planting colonies, as in pre-Columbian times.

SHANNON McCUNE. (Introduced by Guy-Harold Smith.)
Modern Modification of the Morphology of Heizyo, Tyosen.

Heizyo, or P'yongyang, has been the dominant urban center of northwestern Tyosen, or Korea, for over three thousand years. Its sphere of influence has been fluctuating throughout these centuries. In the last forty years its hinterland has been expanding rapidly and its structure has under-

gone significant changes. Two factors have been of considerable importance in these recent changes in morphology. One is the six-fold increase of population to the present total of 250,000 persons and the associated economic development. The other is the importance of the new transportation facilities, especially the railroad with its offset location. The modifications that have been brought about by these factors in the morphology of Heizyo are discussed with the aid of a series of maps.

PAUL F. MARTIN. (Introduced by Meredith F. Burrill.)
Surface Features of the Matanuska Valley, Alaska.

A grano-diorite batholith, folded and faulted Jurassic sediments, some of them coal bearing, and other metamorphic rocks characterize the bed rock of the Matanuska Valley region. Several intrusive-igneous masses of greenstone rise as dikes and "buttes" through the thick fill of sands and gravels of the valley floor. The nature of the bed rock underlying the Matanuska Graben is unknown.

The valley is separated from the mountains to the north and south by two parallel fault zones. The valley floor is higher to the north than to the south probably because of asymmetrical displacement. A two-week period of earthquake shocks experienced during the field season indicates that faulting is actively taking place today.

Ancient glacial epochs within this area are recorded by extensive modification of the valley walls at a height of nearly 4,000 feet. High lateral features and varved clays found in tributary valleys up to 2,200 feet, record the presence of former ice tongues of greater thickness than is known today. All but the higher mountain tops were covered by ice during some stage of glaciation.

Practically all of the surface features in the valley today are either primary or reworked glacial deposits, with minor features due to wind action.

Four areas of medial moraine deposition are recognized within the valley proper. These are the Palmer, Goose Bay, Big Lake and Nancy moraines. Within the Palmer moraine, there lies a unique system of concentric, flat-topped ridges, presumably deformed by pressure from the Knik area. These steep-sided ridges coalesce into terraces at accordant levels downstream. The full significance of these forms is yet to be determined.

Channels and channeling are strikingly developed in the lower portions of the valley. The position and alignment of some of these forms indicate that drainage occurred across the valley in many places. The asymmetry of the valley floor accounts for such cross-country courses taken by the glacial streams.

Esker development associated with glacial stream activity is concentrated in two areas; that at the mouth of Moose Creek and that lying between the Fish Hook Road and Big Lake. These eskers, of variable sizes, join, diverge and cross one another repeatedly. Extensive terracing is further evidence of the high degree of reworking to which the original deposits of the valley have been subjected but several regions of kames situated among these terraces show that parts of the valley have been but slightly modified since the ice front retreated from that particular section.

ERWIN RAISZ.

New Maps and Methods.

(a) *The transitional density patterns.* This method renders a truer pattern of distribution of several variables than the usual outline maps; the kind and the amount of the variables are shown, by using patterns drawn by heavier lines at denser distributions. The patterns are selected so that they can blend into each other. *E.g.,* the symbol for cultivated land interlaced with grassland and cattle symbols gives dairy country.

Similar technique can be used for any map showing transitional values of variable density.

(b) *Landforms of the Northwestern States.* 1 : 1,000,000 (reproduction 1 : 1,136,000). The largest medium-scale landform map yet published-Features shown by this map are:

1. The clearly visible, 500-mile-long structural line extending from Cape Flattery to the Wallowa Mountains, Ore., apparently a compression fault zone, consisting of sharp splintered fault scarps on the crystalline rocks and narrow folds in the lava.
2. The miniature faults in the lava in South Central Oregon.
3. Extension of the Blue Mountain uplift to the south.
4. "Park and Range" structure in the western part of the northern Rocky Mountains.

The map is based on topographic, geologic, forest, and irrigation maps with extensive help of airplane photographs and the author's surveys by plane and car. The term *landform map* is here proposed for this type.

(c) *Railway traffic-flow map of passenger travel in the N. E. quadrant of the United States.* The map shows the number of trains in one direction on each line, excluding local suburban trains. This is the first map of a large section of the U. S. A. showing the relative importance of lines.

While European maps of the same type disclose an organic, dendritic pattern of trunks and branches, the U. S. railways seem to have a parallel pattern of many trunk lines caused by competing railway companies. A unified system could work with greater economy.

(d) *Population map model of girls' colleges in the United States.* Distribution is shown by three-dimensional blocks. It is easy to prepare and can be readily reproduced by photography. The pattern shows centralization in the west, dissipation in the South and competition in the northeast.

(e) *Land-use map of the World, and of the United States.* To appear in a forthcoming textbook by Darrell H. Davis. The map combines natural vegetation, agriculture and manufacturing and mining, all shown quantitatively with block piles and transitional density patterns. To combine all these factors into a single map is difficult and should be regarded as an experiment.

(f) *Oblique azimuthal equidistant map of the world centered on Boston.* This is the only projection in which all distances and great-circle directions are truly shown from Boston and from Boston only. The chief merit of this map is to show the strategic importance of the Arctic.

(g) *Strategic map of the Mediterranean Sea.* The map is prepared on an orthographic projection to show the relationship to the rest of Europe.

(h) *Relief Model of the United States.* 1:4,000,000. The most detailed relief model of the country on this scale. Prepared with logarithmically decreasing vertical exaggeration.

Mary Jo Read. (Introduced by Glenn T. Trewartha.)
The Populating of the Driftless Hill Land.

Between 1830 and 1870 the population of the Driftless Hill Land rose from approximately 4,700 to 740,000. A series of maps distinguishes growth attributable to excess of births over deaths from growth by immigration and locates areas of emigration masked by rising total population.

Two-and-one-half per cent annual natural increase in population, as established for the Middle West of 1845 by the historian Joseph Schafer, compounded annually for ten years, was the basis for these maps. *Predicted* population of each minor civil division for each decade was compared with *actual* population to find excesses or deficiencies.

During the twenty-year period from 1830 to 1850, when cheap government land was abundant and lead mining was flourishing, immigration far exceeded natural increase. 1850 to 1860 marked a turning point. While the newly opened agricultural lands of the northern two-thirds of the area were receiving large influxes, the southern third showed reduced rates of increase, with emigration from the mining region. The scarcity of cheap agricultural land and removal of government land offices, the close spacing of agglomerated settlements and of farmsteads, and state encouragement of immigration, all support the 1860–1870 map in revealing the Driftless Hill Land as having become a source region for emigrants.

Gordon E. Reckord. (Introduced by Meredith F. Burrill.)
Present Land Use in the Matanuska Valley, Alaska.

Agriculture is the primary use of land in the Matanuska Valley; and yet occupies only a small percentage of the total land area. Other uses are areally insignificant and for the most part closely related to agriculture. Farming is practically confined to a triangular area with apices at Wasilla, Moose Creek and the Knik River bridge. The major area of cleared land is on the riverine terraces bordering the Matanuska River where farms are contiguous because of the uniformly higher land quality. Farms on the moraine in the remainder of the settled portion of the Valley, however, are dispersed because of the differential quality of the land. Fields in both areas tend to be small because of the recency and manner of clearing and the limits of topography. It is estimated that from fifteen to twenty-five percent of the arable acreage is occupied by stump rows or piles unavailable for tillage.

The primary crops are oats, grown with either peas or vetch for hay, and barley, oats or wheat which are harvested for grain feed if they mature properly, and are cut for hay if they do not. Hay crops are distributed widely over the agricultural area but most of the grains are confined to the river terraces south of Palmer. Potato planting is general throughout the Valley and may provide either a cash or subsistence income. Nearly every farm has a garden although there are only a few truck farms, the most successful of which is in the dune area on the edge of the high bank of the Matanuska River north of Palmer. Stump and wooded land is largely in pasture, its most productive use, as the cleared land must be used for crops. Farming for the most part is limited to south-facing slopes, terraces and ridge tops. The shallow depth of soils west of Wasilla has limited agricultural use in that direction. The use of winter cover crops is not common despite the prevalent wind in winter and its effects on unprotected fields.

The region is notable as a pioneer agricultural area depending neither on subsistence nor distant markets. Demand for fresh milk by the Anchorage defense base is inducing expansion of dairying, which makes imperative the previously recognized need for farm units of large size. While the specific advantages of specific tracts of land for particular crops is not yet well known, the land used for crops is, in general, the best for that purpose. The low productivity of thin soils is evidenced by abandonment, idleness and poor crops.

F. L. W. Richardson, Jr. (Introduced by Preston E. James.)
Regional Rehabilitation and Planning.

Mass unemployment of coal miners up to the present emergency has

been one of the serious problems of our economy. After the war, it will doubtless be with us again. Fayette County, southwestern Pennsylvania, site of two synclinal coal basins, the Connellsville and Klondike, promises to become one of the most depressed coal regions in the country. By then, the well-known Pittsburgh seam will be all but exhausted.

In 1937 a charitable corporation, as a first step in rehabilitating the county, started one resettlement project of 50 families. To help in planning, the Harvard Business School was approached to carry out an independent survey in 1939. It accepted and I was assigned the job of carrying out an investigation to be of maximum practical value to the management of the project.

The principal problem was to provide the unemployed miners with a means for making a living. As discovered from superimposing a map of coal properties over one of the unmined coal, the larger companies had enough reserves to keep their men employed for some time. But what was to happen to the rest of the population? What about farming or other industry? Obviously farming could at best be only the answer for a few, as there was insufficient available land for all. On the other hand, because of a large local market and lack of local competition, it would seem possible to introduce new industries. For these reasons, as part of the resettlement project, a sweater factory was started, where the labor problems forced the investigator to recognize certain *regional* patterns vital for adequate *community* planning.

The community proved too small to draw an adequate labor supply. Yet to go outside for labor was to invite trouble from the less able workers within. It had been assumed that the old-fashioned community was the most desirable unit for resettlement, because of the "social values" to be derived. It became important therefore to find out more about communities and discover their function in the region. Two maps were prepared, one for the late nineteenth century, the other for the present, indicating the population centers and rural gathering places, such as churches, schools, stores. Next a map was drawn showing the direction of movement of people to the various gathering places in order to demarcate trade and other such divides. The results were startling. In the late nineteenth century, a number of independent farming communities were relatively self-contained social-economic units; at present they have disappeared, and the whole area has become suburban to one town of 10,000. Once the social-economic center with umland was the country village and surrounding farms,—it is now the town and suburbs.

Since the coal is rapidly being exhausted, what future is there for this urban center and umland? What will keep the people, the stores and other

services from leaving? If the town goes, what about the satellite resettlement project? To keep the latter suburb from being dragged down, the unit town center and umland will have to be stabilized.

JOSEPH A. RUSSELL. (Introduced by George B. Cressey.)

Fordlandia and Belterra, Rubber Plantations on the Tapajos River, Brazil.

This paper is a report on progress achieved at Fordlandia and Belterra, Ford Motor Company rubber plantations situated on the Tapajos River, Brazil.

Except for an adequate supply of labor, minimum natural and cultural requirements for rubber cultivation are fulfilled at these two sites. Temperatures in the Santarem district average about 80° F., and have an annual range of less than 5° F. Rainfall conditions are not altogether satisfactory: the eleven-year average at Fordlandia is 82.8 inches, and a three-year average at Belterra is 92 inches. These figures do not indicate the erratic individual yearly conditions nor the protracted drought between July and October.

The two plantations are essentially different in relief, drainage, and soil characteristics. Fordlandia was located on the rough plateau remnant about 84 miles south of the confluence of the Tapajos and the Amazon, and Belterra was laid out on the smooth top of the Brazilian plateau, only 30 miles from the Amazon. The rough topography at Fordlandia set its stamp on every phase of the plantation experiment. The valleys have poor drainage, and proved to be incubators of plant disease; the steep slopes washed seriously and necessitated expensive terracing and cover cropping and irregular planting areas. These conditions resulted in the abandonment of nearly 5,300 acres, and the maintenance of the rest of this plantation as an experiment station. The land surface at Belterra is smooth, dipping southeastward at about seven feet per mile. Soil drainage is adequate. Soil wash is unimportant and absolute freedom of plantation layout is allowed by the flat surface.

Land and capital are available in amounts large enough to insure the success of the plantation, but the presence of several fungus and insect diseases has proved a handicap to the development of the Ford plantations. The labor problem is critical. In March, 1941, there were 2,723 laborers on the plantations, and the 76,000-acre goal of the project will require about 11,000 workers. This number cannot be satisfied within Brazil, and there are serious difficulties to the importation of workmen from abroad.

In March, 1941, there were 3,375,767 trees planted on 16,980 acres of land on the two sites. Of these, 1,390,896 trees were budded, and 88,500

in production. Latex collected amounted to 53,015 pounds. Production at present is in the neighborhood of 2,000 pounds a day.

The Ford experiment has proved that plantation rubber can be grown in Amazonia. Optimistic estimates predict that 6,000–7,000 tons will be produced annually by 1948. Experience gained at Fordlandia and Belterra should help future plantation operators to avoid some of the difficulties to plantation production in Tropical America.

EARL B. SHAW.

Recent Changes in the Banana Production of Middle America.

Significant changes are taking place in the banana production of Middle America. Disease has caused a disastrous decline in yields and an increasing cost in growth and preparation for market. For example, the banana export of Honduras, long the leading banana producer of the world, dropped from 27,700,000 stems in 1930 to 11,200,000 stems in 1938, a condition for which Sigatoka (*Cercospora musae*), a banana leaf disease recently invading the American Mediterranean lands, is almost entirely responsible. The large fruit companies can control Sigatoka, but only at a great additional expense to normal production costs.

Further expense is being added by supplementary irrigation facilities on Atlantic coast plantations. In Honduras all United Fruit Company fields are equipped with artificial water supply, and in Guatemala the company plans to increase the 25 per cent of total banana acreage now supplied with irrigation to 100 per cent within a short time. Although average precipitation figures for Atlantic coast plantations show little need of irrigation, the statistics for individual years explain the necessity for additional water during certain months.

Sigatoka has accelerated the migration of the banana industry—a migration already well started years ago as a result of soil depletion and Panama disease—from the Atlantic to the Pacific coast of Central America. Production figures for Central American countries during the last ten years illustrate this Pacific trend. A decade ago practically all bananas exported by Guatemala came from the Atlantic coast, but in 1940 production on both Atlantic and Pacific coasts was practically the same. Panama is now producing twice as many bananas on the Pacific lands as on the Atlantic fields. Costa Rica shows a startling change, for as recently as 1934 no fruit was grown along the Pacific Coast. In 1940, however, the Pacific plantations definitely took the lead. In 1930 the total production of the Caribbean Coast of Central America was 38,100,000 stems, that for the Pacific Coast 2,800,000 stems; in 1940 the figures for the Atlantic shores were 23,400,000 stems and for the plantations of the Pacific 10,000,000 stems.

PAUL A. SIPLE. (Introduced by Samuel Van Valkenburg.)

American Exploration of Pacific Quadrant of Antarctica.

In 1929 the Pacific coast of Antarctica was unknown from King Edward VII Peninsula in Long. 155° West to Charcot Land in Long. 75° West, a distance of about 1500 statute miles. In the course of four American expeditions the general outline of the coast is now almost completely delineated.

The recent United States Antarctic Expedition with its three exploratory units has added most of the discoveries. Admiral Byrd explored the most inaccessible area between Long. 114° West and Long. 88° West by short observation flights from the Barkentine *Bear*. The outstanding land feature of this region is an extensive peninsula extending to a northern limit of Lat. 71° 45′.

East Base, which was situated on the west coast of Palmer Land, proved the insularity of Alexander Land and Charcot Land, and mapped the coast westward to Long. 185° West, leaving only a small gap to interpolation.

West Base, under the direction of the writer, reoccupied Little America on the Ross Shelf Ice, and by means of modern aerial survey technique remapped the front of the Ross Shelf Ice, as well as much of the interior. The area studied from the air covered 300,000 square miles, whereas that portion mapped in considerable detail was comparable in coastal extent and area to the state of California. New territory explored on this most recent expedition extended eastward to almost the 123rd meridian west, within 150 miles of the area adjacent to it explored in 1940 by Admiral Byrd.

The coast east of Ruppert Cape, seen for the first time in 1940 from the air, is unapproachable from the sea because two active glaciers debouch into shallow waters and the littoral ice is prevented from floating away by partial grounding and blocking by two or more islands. The larger of the two glaciers is approximately 18 miles wide and drains an area of at least 3,000 square miles from interior mountainous land rising to peaks over 10,000 feet high.

Beyond the 135th meridian eastward the open sea reaches the clearly defined coast which is marked with rock exposures and shelf ice. A large conical-shaped mountain, suggestive of volcanic origin, forms a massive headland near Lat. 73° 15′ and Long. 123° West, rising to an estimated height of about 15,000 feet. The physical aspects of the region present a high interior guarded by lower coastal mountains, mostly of igneous or metamorphic character.

Land parties which established ground controls for mapping have studied in considerable detail the geology of the Edward Peninsula and the Edsel Ford Mts. of Marie Byrd Land, and have made reconnaissance studies of climate, flora, fauna and bacteria.

J. Russell Smith.
Suggestions for Illustrating Books.

1. The use of spheres to indicate relative quantity or number.
2. The proper method of numbering illustrations.

Nicholas J. Spykman. (Invited paper.)
Frontiers and the Problem of Security.

I. *International Society*

The international society, in contradistinction with the national society, is composed of free and independent social units which use war as an instrument of policy. In periods of feudal and state organization, the group structure is territorial and social preservation demands defense of territory, of the fuedal or the national domain.

A. *Individual security*—The problem of security for the individual state involves the attempt to compensate for the inequality in strength between itself and its potential enemies.

B. *Collective security*—The problem of security for the international community involves the attempt to compensate for the inequality in strength between the individual units, that is, to balance power.

II. *Frontiers*

In the search for territorial security, states strive for protective frontiers.

A. *Natural frontiers* with strategic value.

B. *Artificial frontiers* with strategic value.

1. Linear—walls, limes, frontier fortifications, Maginot Line.
2. Zonal—waste land, demilitarized zone, march, buffer state, neutralized state.

III. *Frontiers and Warfare*

The protective value of natural frontiers and artificial fortifications is dependent on the nature of warfare. History shows three cases in which exceptional mobility, developed by one of the opponents, has created special problems for security.

A. The invasions of the horse-riding nomads on the frontiers of the then civilized world.

B. Mechanized warfare in the Second World War.

C. Aerial warfare in the Second World War.

The most important of these is the development of aerial combat which has made war three-dimensional and has invalidated the whole concept of the protective frontier. If the effective range of planes had remained limited, safety might have been found in the development of protection through zonal types of frontier. But the increase in effective radius con-

tinues to progress and this approach therefore seems to offer no real solution.

IV. *Conclusion*

Mechanized warfare and aerial operations have complicated not only the problem of individual security but also the problem of collective security. Attack is speedy and defense by collective action is slow and cumbersome. If the international community resists at all, it is likely to act too late.

Because frontiers have lost their defensive value, because buffer states have lost their protective function, and because collective action cannot compensate speedily enough for power differentials between individual states, it becomes imperative to strive for approximate equality in strength in the units of the international society.

Otis P. Starkey. (Introduced by Lester E. Klimm.)

Population Changes and Industrial Changes in the Williamsport, Pennsylvania, Area.

A series of maps shows that, since 1890, the population has declined steadily in most rural parts of the Williamsport trading area. During the same period the population has increased in and about the cities of the middle Susquehanna Valley. The decreases in population reflect the decline of the lumber industry and, in some cases, the decline of farming and coal mining on the Allegheny Plateau. The increasing population in the Susquehanna Valley reflects the success of local businessmen in creating or attracting new businesses to replace lumber milling and associated industries.

Local capital, accumulated during the lumber boom, was at first the principal factor in attracting new industries. Almost equally important was the supply of skilled labor, developed at first in industries serving the lumber business and later through trade schools and apprenticeships. Location at an important railroad junction and division point, central location in relation to large Eastern urban areas, and an active chamber of commerce, also were important factors in attracting industry. As a result of these factors, the following types of industries were developed: metal products (rolling mill products, motors, valves, boilers, furnaces, wire rope); textiles (silk, knitgoods, clothing); woodworking (furniture, flooring, doors); leather products (sole leather, glue); and paper products (crepe paper, novelties, boxes).

Henry Somers Sterling. (Introduced by Preston James.)

Basic Problems of the Agrarian Program in Central Mexico.

The greater part of Mexico's program of ejido distribution—the most

drastic experiment in the agrarian history of the Americas—has been carried out within the last seven years. Now that it has gone as far as the law allows, in the more densely inhabited portions of Central Mexico, the government is working on the second stage of its agrarian program, during which it hopes to solve certain serious problems created during the first stage.

The most fundamental of these is the abysmally low living standard of the average ejidal family. Of the many causes for this, two basic ones are here considered: the critical overcrowding of many ejidos, and the decreased carrying capacity of ejido land. The latter is due partly to less efficient methods, and partly to a widespread shift from cash to subsistence crops.

The general overcrowding of ejidos is so pronounced that in certain districts the average ejido family has less than a hectare of land. Probably a third to a half of the ejidal families of states such as Mexico, Hidalgo, Tlaxcala and Puebla live in newly created rural slums, in which they cannot maintain even a marginal existence from the land alone.

Save where corn, the basic subsistence crop, cannot be successfully grown, the ejido has too often become simply an extension of the largely self-sufficient village economy. Among the causes for the abandonment of cash crops in many areas are:

1. Reversion of the Indian farmer to his self-sufficient culture habits.
2. Destruction of essential processing plants for such crops as sugar and coffee.
3. Allotments too small for the profitable production of commodities such as maguey, sugar, milk or livestock.
4. Uncertainty as to the permanency of ejidal allotments, which has often discouraged the growing of perennial crops.
5. "Waiting" costs incidental to the production of perennial crops such as maguey.

To improve the generally low ejido living standard, the government must either give the individual ejidal family more land, or make its present allotment more profitable. Some progress is being made in the first direction, through a re-census of ejidal families to eliminate ineligibles and absentees, and resettlement of surplus population in Mexico's thinly inhabited peripheral areas—a slow, difficult, and costly process. Another possibility, so far avoided, is the subdivision of land still legally preserved in private detached farms.

For more immediate results, the government has been devoting its limited resources to helping the conservative Indian farmer increase the income from his land. Through agrarian education and financial aids, it

hopes slowly to induce crop diversification and technical improvements. By cooperative or collective operation of ejidos in certain districts it seeks to retain or restore some of the relative efficiency of the hacienda. It is improving highway access to urban markets, and introducing new processing plants and irrigation systems.

We cannot fairly gauge the results of these experiments until they have been conclusively tested over a period of several decades.

KIRK H. STONE. (Introduced by Meredith F. Burrill.)

Land Tenure and Sequent Occupance in the Matanuska Valley, Alaska.

The examination of land tenure and sequent occupance in the Matanuska Valley, Alaska, has been based in this study on the General Land Office records, supplemented by field investigation of land transfers and areal history.

Three periods appear to have existed in the development of the valley. (1) About 1910–1915, when early white settlement began in the southwestern part, around the Indian village of Knik. This was for the purpose of farming and the pasturage of horses used in the Talkeetna Mountain gold mines at the north edge of the valley. (2) 1915–1935, the period of homesteading, for farming and some fur farming. The center of settlement had shifted northeastward to Matanuska and Wasilla villages for easier transportation to markets outside the valley. Gold concentrate collected at Wasilla and the Upper Matanuska Valley, coal collected at Matanuska was shipped to outside markets via the Alaska Rail Road. (3) 1935–present, the period of the government-aided, agricultural, colonization experiment. The center of settlement had shifted to Palmer, in the east-central portion, near where the road to Anchorage crossed the Matanuska River.

At the beginning of this third stage, there were four types of land parcels in the valley: (1) vacant and unappropriated, (2) entered but relinquished, cancelled or withdrawn, (3) privately owned, and (4) colony reserve (under the control of the Alaska Rural Rehabilitation Corporation). However, the maps show that this classification is too simple for understanding present land tenure in the valley. With control of the land the determining factor the parcels are classified now as: (1) patentee-occupied, (2) patentee-owned rented, (3) colony-owned colonists, (4) colony-owned rented, (5) corporation-community tenant (hay reserve), or (6) unoccupied (cancelled, relinquished or withdrawn claims, patented land or land never entered).

Examination of the homestead parcels still occupied by the patentees is useful in the determination of land types suitable for agriculture as practiced in the valley. The main concentration of these parcels is near the

valley's center, to the southwest, south and southeast of Wasilla. About one-third of the acreage of this type has been occupied from 20–26 years and the average length of time that the patentee has been on his land is 14 years.

A large area of relinquished, cancelled or withdrawn parcels is found west of Wasilla along the railroad and three smaller concentrations are located between Wasilla and the Chugach Mountains east of Palmer. The study of these and the parcels occupied by patentees for a relatively long period indicates to some extent the character of the land in the valley.

H. THOMPSON STRAW. (Introduced by Preston E. James.)
An Area Analysis of Humphreys County, Tennessee.

A. Current Problems

1. To increase the average income of the farms and thus to help reduce the relief loads.
2. To improve forest yields.
3. To aid in the resettlement of farmers dispossessed of owned or rented lands by the creation of the reservoir.
4. To provide vocational training for the many young people who must continue to migrate from the county in the future.
5. To lessen the cost of local government which must be borne by fewer farms after the creation of the reservoir.

B. Recommendations

The following specific recommendations are offered. The land classified as nonfarmland should be devoted to forest. Fire control and proper care and cutting should be practiced so that yields may increase. Further study is needed, especially along the lines of:

1. Whether national, state, or private control can best accomplish these ends.
2. If privately controlled, whether a tax system such as the deferred timber tax recommended by the U. S. Forest Service might not be desirable. Reforestation by the T.V.A. especially near the reservoir, should continue. The landowners of the area which is to be flooded by the T.V.A. reservoir have been paid and are able to move elsewhere and purchase new farms. The numerous tenants of this area, however, constitute the chief problem. The proposed diked area which will be leased by T.V.A. to former tenants will provide a partial solution. Further recommendations include the continuance of T.V.A. help by maintaining an Assistant in Resettlement in the office of the County Agent, and F.S.A. loans to encourage former

tenants to become farm owners elsewhere. The Buffalo River bottoms will continue in cultivation and should have the continued aid of the T.V.A. and the Tennessee Extension Service with test-demonstration farms. The major problem of this area seems to be low farm incomes, largely resultant from improper farm practices. The McEwen Upland and the Ridge and Valley area should have greater emphasis placed upon forestland and pastureland to augment the income from present cropland. State aid in forest-fire protection and in the test-demonstration farm program and from T.V.A. through its fertilizer distribution program are recommended. The possibility of establishing more factories such as those at McEwen for canning tomatoes and making cheese, thus increasing the farm income and providing additional employment, should be studied. Every possible aid and cooperation should be given the community study projects which cover the western part of these areas. Many of the people on the River Terrace land have been accustomed to rent land on the bottoms for crops. The proposed diked area will not be sufficient for their future needs. Aid from the T.V.A. and the F.S.A. is necessary to relocate some of them.

Additional recommendation for the State would be a constitutional amendment enabling a consolidation of counties, thus allowing a decrease in local tax burdens and an increase of services, especially aid in vocational training which will be sorely needed in the future.

W. Russell Tylor. (Introduced by Derwent Whittlesey.)
Sociology of the Region.

A new current of thought in American social science known as Regionalism has emerged. This is attested not only by the volume of studies and articles in leading social science journals which deal with the subject in one or more of its many forms, but also by the great importance attached to the regional approach by its leading sociological exponents.

As a sociological concept and discipline the region may be defined as any more or less culturally homogeneous geographic area larger than the single community, regardless of size. In brief there are major and minor regions. Sociologists have developed the concept on the basis of a multifactorial analysis, and the whole field of study may be encompassed from two interrelated interpretations, *viz.,* the theory and the practise of regionalism.

The theory of regionalism deals with the region as the product of sociological research and analysis, regarding which two important types of

studies are reviewed. Regionalism in practise involves its implementation in organizations and programs for the planning, development, administration and control of regions.

Major regional planning organizations comprise groups-of-states regional planning associations like the New England and the Pacific Northwest Regional Planning Commissions or Councils; interstate compacts like the Colorado River Compact and the Port of New York Authority; various other forms of voluntary interstate cooperation; the state planning commissions themselves; and superlatively, a federal regional authority like the Tennessee Valley Authority.

Minor regional planning organizations would include the county regional planning commissions throughout the nation, together with several groups-of-counties districts; and especially the metropolitan regional planning associations, which comprise the metropolises with their commuting urban-rural hinterlands.

In addition, the administrative regions of the various departments of the federal government, and the operative regions of large private business and social welfare organizations of all kinds likewise come into the picture.

Since all of these organizations are increasingly emphasizing the significance of their activities as these bear upon the social structure and functioning of the regions concerned, the study of their forms, development, objectives and accomplishments becomes one of basic concern to the sociologist.

In short, the interest of the sociologist in the region is grounded not only in theory but in fact.

SAMUEL VAN VALKENBURG.

Structure and Value of Italian Agriculture.

At the International Congress at Amsterdam in 1938, Dr. Ellsworth Huntington presented a paper on evaluation of agriculture based on an agricultural index system. The author of this paper has continued this work, which was only in a preliminary stage, and has used Italy as an example to show the advantages of the system; he expects later on to publish his results for other European countries and for Europe as a whole. The value index system in which all crops are evaluated in their relation to the standard, based on the relative value of a mixture of wheat, barley, and corn, has the outstanding advantage that it makes crops directly comparable.

In the paper presented here, three types of use are illustrated: (1) for one crop (example, wheat) in its relative and absolute position in Italian agriculture; (2) relative and absolute value of total Italian agriculture by provinces; and (3) the complete structure of Italian agriculture shown by provinces and used for the construction of agricultural regions.

STEPHEN S. VISHER.

Precipitation Regions of the United States.

Lantern slides were shown of eleven maps of precipitation regions drawn on different bases. A few of these maps are redrawings of published maps, some are simplifications of more detailed maps, and the others are original. Maps shown are (1) snowfall amounts, (2) thunderstorm frequency, (3) hail frequency, (4) seasonal distribution of precipitation, (5) half-years with most precipitation, (6) daytime versus night rains, (7) maximum rainfalls in various intervals of time, (8) regions of rainfall intensity, (9) average deviation from normal precipitation, (10) adequacy of rainfall, (11) average annual runoff.

These maps reveal such wide regional contrasts in these significant aspects of precipitation as to justify a sub-division of the United States into twelve precipitation regions, instead of into the three commonly recognized (arid, semi-arid, and humid). The final slide shows these twelve regions, as tentatively delimited from available data, including scores of maps of regional contrasts in precipitation not here shown, for lack of time. These regions are (1) The Deep South (Gulf Coast), (2) The Upper South, (3) The Lower North, (4) The Upper North (the Canadian border), (5) The Northern Prairies, (6) The Northern Great Plains, (7) The Southern Plains, (8) The Southern Rockies and Plateaus (especially New Mexico), (9) The Northern Cordillera, (10) The Great Basin, (11) The South Pacific Coast, (12) The North Pacific Coast. The precipitation characteristics of each of these regions were given.

DERWENT WHITTLESEY. (Invited paper.)

Geography into Politics.

Reconstruction after this war will fail unless it takes account of ingrained political attitudes of the populations concerned, and accepts the realities of the earth's structure as the nature-given frame of territorial arrangements.

The German population has adopted a political attitude toward area not found elsewhere. Its formulation crudely defines the overlap between geography and political science, and is known as "geopolitics."

The framework of geopolitics was erected by geographers about 1900. Shortly before the First World War geographers and political scientists brought the earlier work into focus. The war relegated the subject to obscurity; the peace brought it to the fore. In 1924 the *Zeitschrift für Geopolitik* became the principal outlet for studies in geopolitics. With the rise of the Nazi power German geography was merged in geopolitics.

The doctrine rests on four major tenets:

1. The state has a right to adequate living space for its population, and to natural resources which will make it self-sufficing.

2. The state is an organism, subject to laws akin to those of biological organisms.

3. The inherent importance and vigor of a state lies in its position, and central location is the ideal. A corollary is the inevitable conflict between landpower and seapower, to the assumed disadvantage of seapower.

4. Geopolitics is "the dynamic way of thinking about the state," using facts of the past and present as a basis for predicting the future.

The program of geopolitics points to change as the normal condition of a state. In applying the four tenets to Germany, Central European history has been rationalized to serve as a foundation for the program, particularly the traditional push of German states (notably Austria and Prussia) to the eastward. As the cornerstone of the program, renewed expansion is agitated. This looks first toward the creation of Pan-Germany. As a stage in the superstructure of an expanded German state, it is proposed to push on across Russia, as the geographic pivot on which political integration of the earth's landpower can be mounted. Next comes the overthrow of seapower —in the fringe of maritime states on the margin of continental Europe; in Britain and Africa, which together with Western Europe form the eastern shoreline of the Atlantic Ocean; in the Americas. The Orient may conceivably be approached as the last stronghold of seapower, or more directly overland across Eurasia.

The method of geopolitics accepts war for conquest as the norm. Conquest is carried out piecemeal, not in a rigid and foreordained order, but as expediency dictates. Each step it taken according to matured plans of the Army General Staff. Propaganda is essential to the method. The background of geographic scholarship possessed by writers of this propaganda lends an air of veracity to their work, and appeals particularly to Germans who, by education or temperament, remain unimpressed by Nazi oratory.

Geopolitics has become an engine of political society. It accumulates information for the service of the state, and it functions through propaganda as an arm of government. Originally rooted in geography, geopolitics has been moving over into the field of politics. Study of both its geographic and its political aspects is needed, because of the large part it plays in the thinking of the German people.

LEONARD S. WILSON. (Introduced by Preston E. James.)
An Area Analysis of Mercer County, Kentucky.

A. Current Problems

1. No opportunities for employing the normal increase in working population. A closing of existing openings is taking place.

2. Withdrawal of crops from Maury Lands has accompanied the extension of "horsefarm" economy in the county. This has resulted in a decline in the number of share-croppers and tenant farmers.
3. Expansion of crop production on Eden, Mercer, and Dix lands has accompanied the expansion of "horsefarms" on Maury. On these poor lands greater emphasis has been placed on cash crops to enable the families to obtain their necessary food, clothing, and shelter. This has resulted in 80% of the farms on these lands being too small for the application of sound agricultural and economic practices.
4. Complete lack of opportunity for any work other than farming and an absence of any community skill for other employment has resulted in the break-down of family and neighborhood groups. In turn this has caused a floating population of migrant workers who must find employment in other areas in order to augment their sub-standard incomes.

B. Recommendations

The program must encourage the proper use of abundant resources in an attempt to solve the problem of seasonal employment and the lack of work opportunities. The following steps should be taken:

1. County officials should establish rural zoning ordinances to expand holdings on Eden, Mercer, and Dix Lands to a minimum of 120 acres per unit at a cost of $5,000 per unit. Reduce Maury farms to 100 acres per unit to encourage crop production. Withdraw much Mercer and all Dix from agriculture and livestock production. Encourage the recreational use of these lands as well as the water and historical resources of the county. Encourage the wool industry through education.
2. State officials should expand vocational training. Examine mineral resources. Encourage new crops and grazing industries (hemp). Press tax delinquency foreclosures on sub-marginal lands.

LEONARD S. WILSON. (Introduced by L. M. Gould.)
Population Trends in Minnesota—1940.

The pattern of population in Minnesota in 1940 shows several significant departures from the pattern which has developed during past decades. The major cities have slowed in growth until they are now increasing in size at approximately the same rate as the population of the state as a whole. Marked expansion has taken place in urban centers of moderate size, while the smallest towns have declined in both size and number. Rural population continued to show relationships to the fundament but the details of location indicate that less attention is being given to the potentialities of the

land. Population distribution in 1940 is represented by a dot map based upon the returns of the Census by Minor Civil Divisions.

Of more significance than the present location of people are the incipient trends which, if continued, will lead to a different distribution of population in the future. An examination and comparison of the growth trends during the 1930–40 decade with those of the 1920–30 period show that the most rapid growth of population is taking place on lands which are poorly suited for agriculture but are well equipped for recreational and forestry uses. Preliminary returns of the 1940 Census of Agriculture indicate that these pioneers are attempting to establish a general farming economy in the northernmost counties of Minnesota. Since these lands are close to the climatic limits of the crops being planted, any slight deviation from anticipated weather may result in economic disaster to the people involved. As a result these lands of excessive population growth may become the problem areas of Minnesota at a future time. General farming should be discouraged in the areas which at present show the most rapid growth in rural population.

Symposia at the New York Meeting

Several of the papers abstracted on the preceding pages appeared as parts of symposia. For convenience in finding them, the titles are here regrouped as they appeared on the program.

A. *Southern Studies.* Eight selected counties of the South were studied by eight different men in accordance with a technique for "area analysis" worked out in the Land Committee of the National Resources Planning Board. Summaries of their findings formed the basis for discussion. The abstracts include only two sections of their analyses: a statement of current problems and recommendations for readjustment. These excerpts will be found under the names of the participants, listed below.

Rollin S. Atwood: Alachua County, Florida
Alfred W. Booth: Decatur County, Georgia
Franklin C. Erickson: Chatham County, North Carolina
J. Sullivan Gibson: Sumter County, Alabama
Walter Hansen: Denton County, Texas
Clyde F. Kohn: Lowndes County, Mississippi
H. Thompson Straw: Humphreys County, Tennessee
Leonard S. Wilson: Mercer County, Kentucky

B. *Matanuska Valley, Alaska.* Five papers arranged by Meredith F. Burrill, based on field work done in 1940 and 1941.

Meredith F. Burrill: Land Classification
John Leighly: Climate
Paul F. Martin: Surface Features
Kirk H. Stone: Land Tenure and Sequent Occupance
Gordon E. Reckord: Present Land Use

C. *Problems of Post-war Reconstruction.* Three invited papers presented before a session held jointly with the American Political Science Association.

Derwent Whittlesey: Geography into Politics
Richard Hartshorne: The Nationality Problem in the Shatter Zone of Eastern Europe
Nicholas J. Spykman: Frontiers and the Problem of Security.

Exhibits at the New York Meeting

A hall convenient to the meeting room afforded space for an ample showing of cartographic materials.

A large number of exhibits illustrated or supplemented papers on the program. These are listed below.

Hoyt Lemons.—Twenty-five maps of times and places of hail-storms in the United States, showing average occurrence grouped into three degrees of damage.

George Cressey.—Two maps of landforms of New York State.

Harry E. Hoy.—A physiographic diagram of Mexico.

Webster F. McBryde.—Twenty-three maps and map plottings of southwestern Guatemala, showing physical elements (geology, with cross sections, climate, and vegetation) and cultural data (colonial economics, modern house types, agriculture, crafts, and markets, including two detailed diagrams of major markets having some 1500 vendors each).

Leonard Wilson.—Three maps of population trends in Minnesota.

F. L. W. Richardson, Jr.—Eighteen maps of a resettlement project in Western Pennsylvania, showing occupance in relation to physical environment, and relations of settlements to each other.

Otis P. Starkey.—Three maps and one graph of changes in population and industry in the Williamsport (Pa.) area; by minor civil divisions. Also a line-block traverse of Schuylkill County, Pa.

Erwin Raisz.—A variety of maps by Dr. Raisz and his pupils. In addition to those listed in his abstract (*q.v.*), were equidistant projections of the world with Germany and Japan at their centers; also the earth as seen from the sun.

Henry J. Bruman.—A map spotting the Mexican areas covered by the *Relaciones Geográficas,* and facsimiles of a dozen pages, including two maps.

Most or all of the contributors to the Southern Studies Symposium displayed maps of their respective counties. These covered natural environment, particularly soils, land-forms and land use, dot maps of individual crops, and a wealth of other data.

Showings not related to papers were numerous and varied.

Maps by the U. S. Bureau of Agricultural Economics of land use and control classes of range sheep in the Northwest.

Nine items published recently by the Geographical Press, including a

geological map of the United States. Also a manuscript map by A. K. Lobeck of the geology of northeastern United States.

Photographs by Wallace W. Atwood, Jr., of parts of the Babson relief model of the United States, recently completed at Wellesley Hills, Mass.

A political map of Brazil published in 1940, hung by Jorge Zarur, Whitbeck Fellow from Brazil at the University of Wisconsin.

About twenty manuscript maps and perspective views by Richard Robinson, who calls them "drawings of non-existent models." Some were in black and white, others were colored according to the formula developed by Mr. Robinson. Many of them have been published in *Fortune* and elsewhere.

"The Map of the Americas," scale 1 : 5,000,000, of the American Geographical Society. Seventeen maps were hung showing the steps in the production of a finished sheet of this series.

The American Geographical Society Building was replete with exhibitions covering several aspects of cartography. Conspicuous among them was the almost completed Millionth Map of Latin America.

Dr. Walter Ristow, Chief of the Map Division of the New York Public Library, prepared for the geographers' meetings an exhibition in the Library of "The Western Hemisphere in Maps, 1492–1942; 450 Years of Cartographic History." On permanent display in the Library is the Stokes Collection of rare maps of New York City.